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THESIS

An Accuracy Analysis of The Army Materiel System Analysis Activity Reliability Growth Model

by

Donald Paul Amiotte

June 1980

Thesis Advisor: W. M. Woods

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T195203

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
An Accuracy Analysis of The Army
Material System Analysis Activity
Reliability Growth Model

5. TYPE OF REPORT & PERIOD COVERED
Master's Thesis;
June 1980

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Donald Paul Amiotte

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE
June 1980

13. NUMBER OF PAGES
159

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Reliability Growth, Statistical Model, Analysis,
Failure Rate Estimates, Performance Plots, Modifications

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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(Page 1) S/N 0102-014-6601

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DD Form 1473
1 Jan 73
S/N 0102-014-6601

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An Accuracy Analysis of The Army Materiel System Analysis Activity Reliability Growth Model

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
June 1980

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ABSTRACT

In this paper, a statistical model known as the AMSAA reliability growth model, is evaluated by measuring how well it tracks various reliability growth patterns. These patterns are defined by specified sequences of failure rates. Monte Carlo simulation is used to generate test data based on a time-terminated test plan. Estimates of failure rates, computed using the AMSAA model, are compared with the specified failure rates. Results for 18 reliability growth patterns are presented in both tabular and graphical form. Four modifications in the use of the model are discussed with selected results of their application presented.

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I. INTRODUCTION

Many methods of modeling reliability growth have been proposed and used with some success. Reference 1 contains a detailed discussion of reliability growth, reliability growth models, and describes several models that are available to the manager for use in measuring reliability growth in his program.

The purpose of this study is to evaluate the accuracy of the Army Materiel Systems Analysis Activity (AMSAA) reliability growth model [Ref. 1] for systems which provide limited test data during the development cycle.

II. THE AMSAA RELIABILITY GROWTH MODEL

The AMSAA reliability growth model is a statistical model that estimates reliability growth trends. It is applicable to systems for which usage data is measured on a continuous scale.

As with most reliability growth models, the AMSAA model uses test data to estimate unknown parameters which are then used to estimate the reliability growth trend. References 1 and 2 develop the AMSAA model in detail. This paper addresses the use of the AMSAA model for sequential, time-terminated testing.

Time-terminated testing occurs when each item is tested until failure or until that item has been tested a specified amount of time. If an item does not fail before the planned test time, then a failure has not occurred and the next item is tested.

For time-terminated testing, the AMSAA model [Ref. 1] provides the following estimate for the failure rate of a type of hardware unit (component, assembly, subsystem, system) at total accumulated test time T on that type of unit;

$$\hat{r} = \hat{\beta}\left(\frac{N}{T}\right) ,$$

where N = number of failures of that type of item to time T

and

$$\hat{\beta} = \frac{N}{N \ln T - \sum_{j=1}^{N} \ln X_j}$$

with X_j = total accumulated test time over all items tested when the j th failure occurs.

Using these estimators, the accuracy of the AMSAA model was evaluated for a variety of reliability growth patterns.

III. TESTING PROCEDURE

Reliability growth models are often evaluated against actual test data. The problem with evaluating a model against actual data is that the failure rate driving the system at any one time is never known, it can only be estimated.

The purpose of this chapter is to describe the test plan under which the analysis was made and define the test organization used. Figure 1 shows the relationship between the elements of the test plan and the organization of the testing.

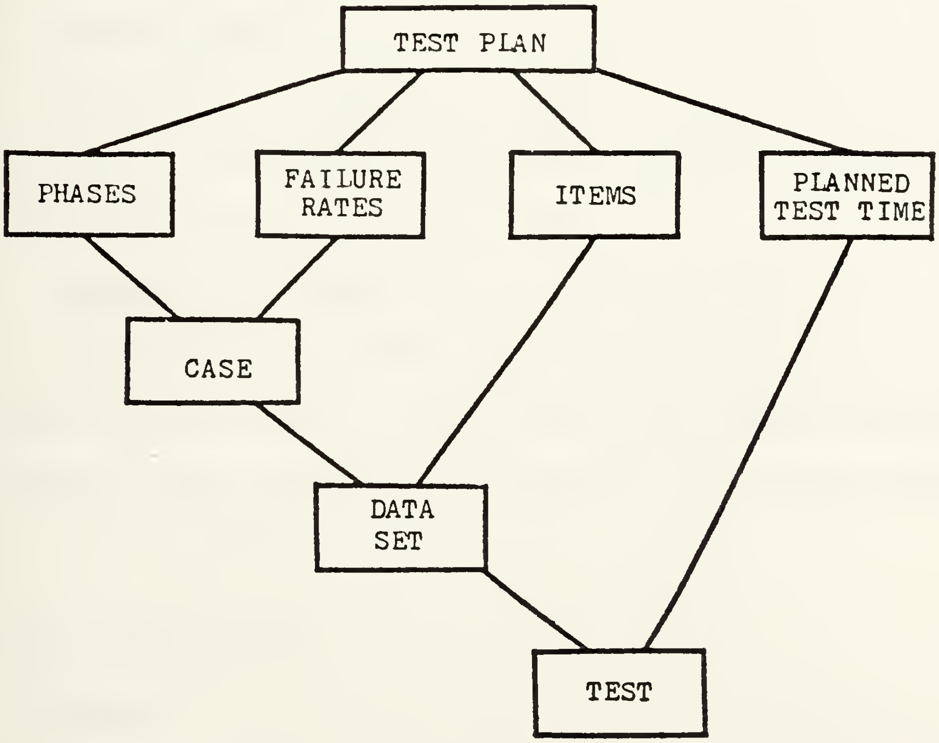

TEST PLAN
PHASES
FAILURE RATES
ITEMS
PLANNED TEST TIME
CASE
DATA SET
TEST

Figure 1. Test Organization

A. TEST PLAN

The key elements of the test plan used for the evaluation of the AMSAA model are described below.

1. Phases

Tests were conducted in phases consisting of testing a specified number of items with randomly generated exponential failure times based on the failure rate specified for that phase.

2. Failure Rates

Each phase had a specified failure rate, which was assumed to be constant for the duration of the phase. The failure rates specified could be different from phase to phase. This set of failure rates defined the reliability growth pattern for a test,

3. Items Tested

A specified number of items was tested in each phase. In this analysis, the number of items tested was the same for each phase in any one test.

4. Planned Test Time

Each item in a phase was tested to failure or until the specified planned test time for that phase was reached. The planned test time was the same for all items tested during any one phase.

B. TEST ORGANIZATION

1. Cases

The AMSAA model was applied to 18 test cases where each case was defined by a set of failure rates and a

specified number of phases. The general shape of the various cases, classified by number of phases and by trend of growth, can be found in Figures 2 through 5. Test phases are plotted, equally spaced, on the horizontal axis and failure rates are plotted on the vertical axis.

a. Set of Failure Rates

Each set of failure rates defined a reliability growth curve which was then classified by its general trend of growth into one of two categories:

(1) Non-increasing Failure Rates (Figures 2 and 3)

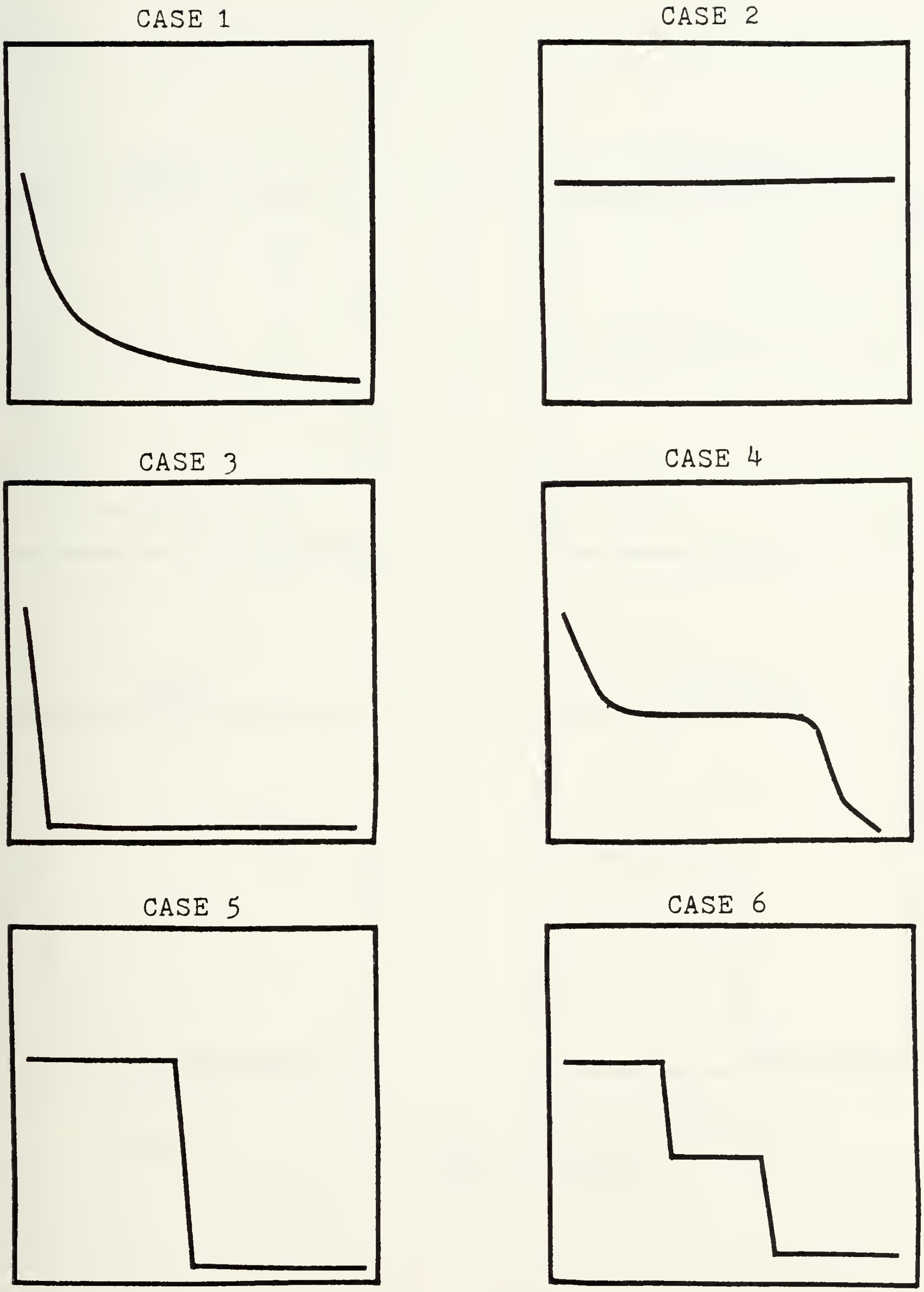
(2) Failure Rates that Increase at least once during testing (Figures 4 and 5)

b. Number of Phases

In addition to their growth trend, cases were grouped, for comparison, by their total number of phases. The two groups are those that have 16 phases and those that have 6 phases.

(1) 16-Phase Cases. Cases 1 through 6 (Figure 2) and cases 13 through 18 (Figure 5) were each defined by specifying 16 failure rates, one for each of the 16 test phases.

(2) 6-Phase Cases. The growth patterns for cases 7 through 12 (Figures 3 and 4) were defined by a set of six failure rates. Some of the cases reflect the same growth patterns shown for the 16-Phase cases, except that, the testing was carried out for only six test phases.



CASE 1

CASE 2

CASE 3

CASE 4

CASE 5

CASE 6

Figure 2. 16-Phase Cases with Non-increasing Failure Rates

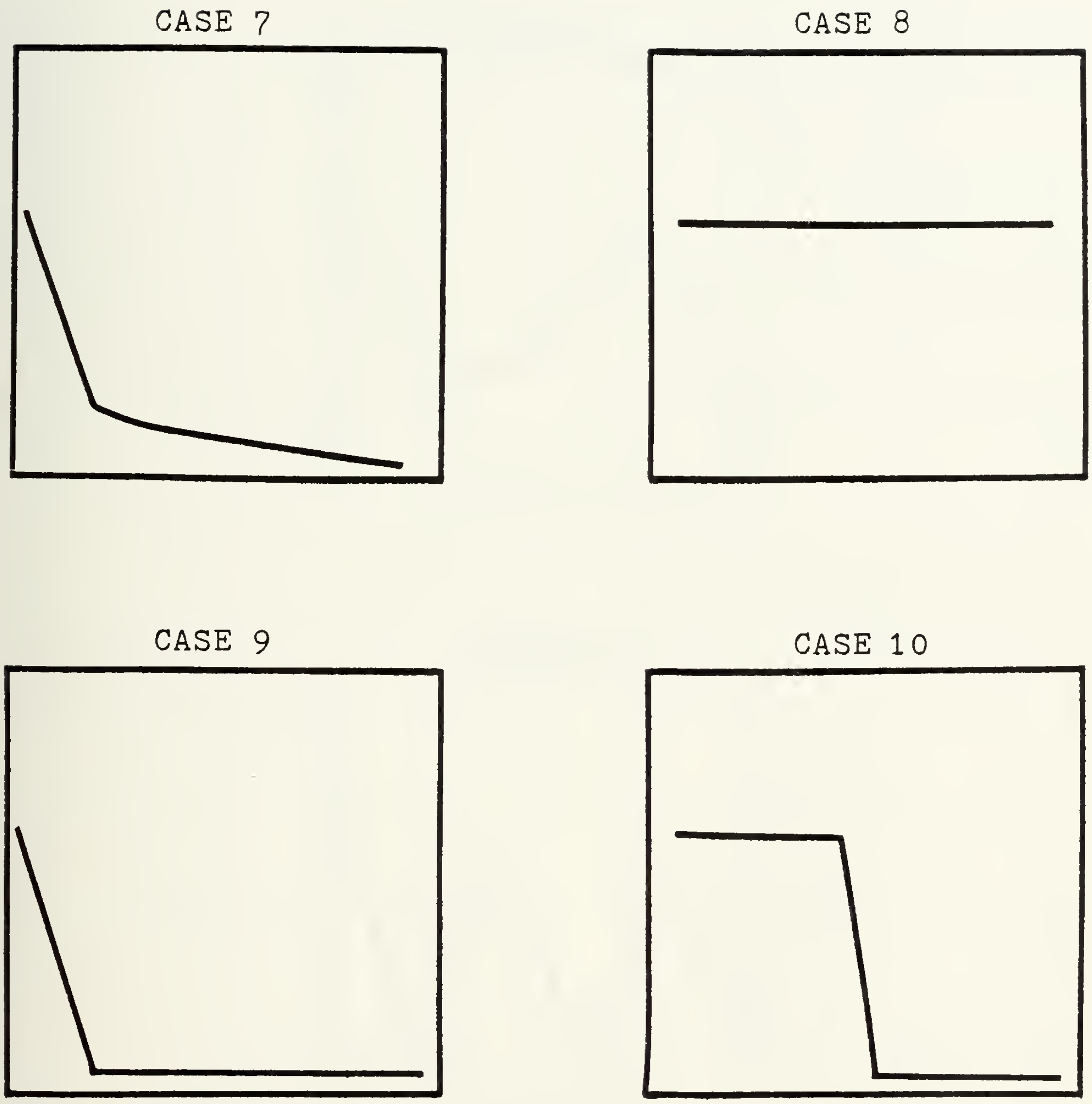


Figure 3. 6-Phase Cases with Non-increasing Failure Rates

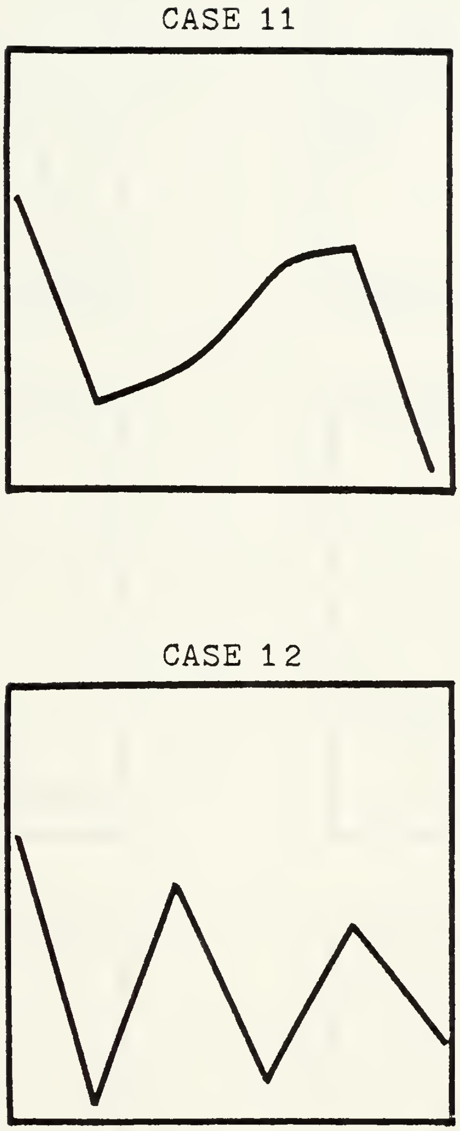
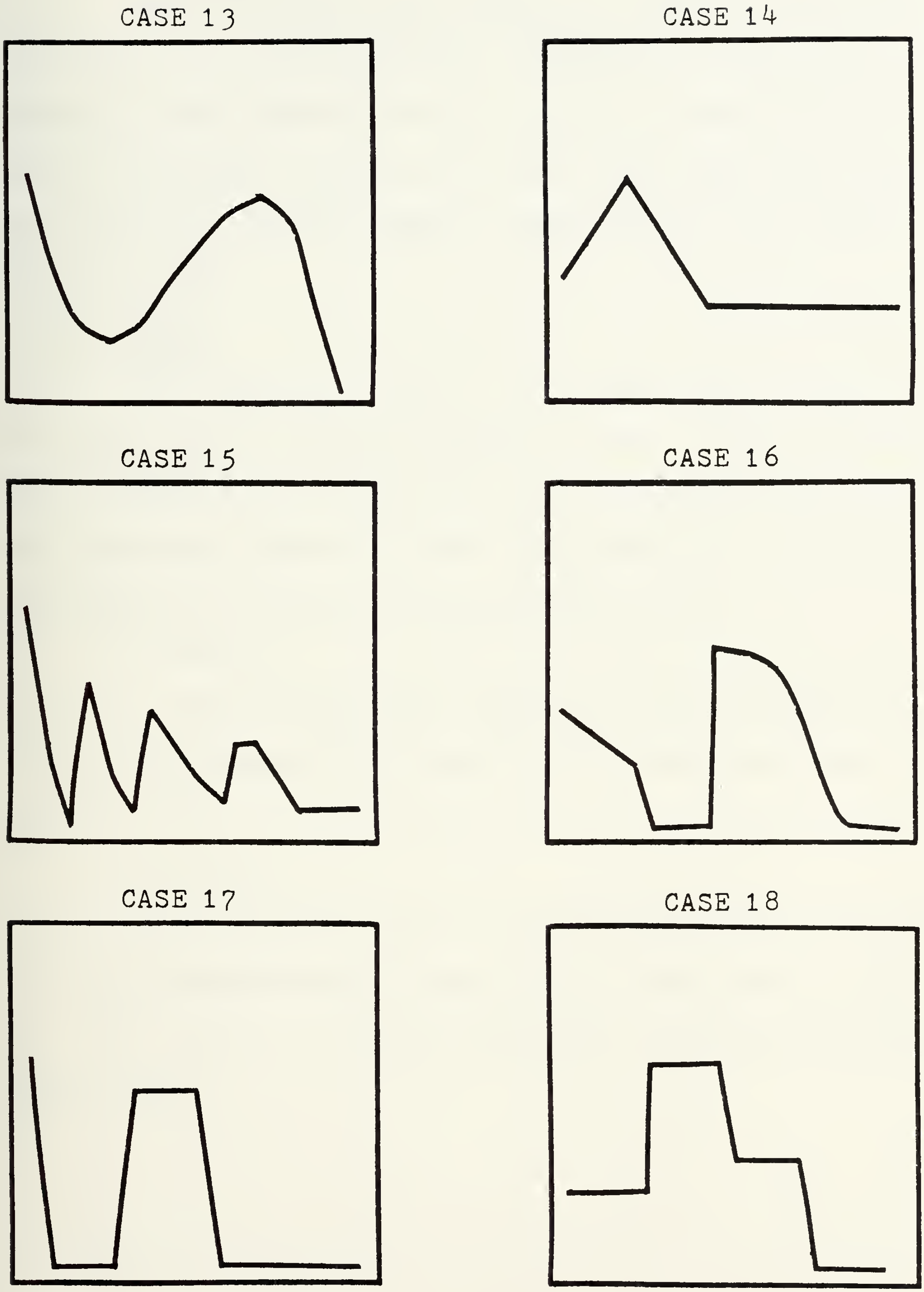


Figure 4. 6-Phase Cases with Failure Rates that Increase



CASE 13

CASE 14

CASE 15

CASE 16

CASE 17

CASE 18

Figure 5. 16-Phase Cases with Failure Rates that Increase

2. Data Sets

Specification of the number of items to be tested in any phase for a particular case resulted in a Data Set. The number of items tested during a phase was the same for each phase of testing. Three sets of test data were generated for each case, one set each for tests with 5, 10, and 20 items per phase.

3. Tests

The remaining element of the test plan, Planned Test Time, was used to define individual tests. Since the failure rate underlying the exponential test times was known, planned test times were chosen so that the probability of survival was such that sufficient failures would occur.

a. Test 1

The planned test times for Test 1 were generated so that the probability of survival for each item would be .85.

b. Test 2

Test 2 consisted of generating planned test times by using a probability of survival for each item of .99. This test was run to see how the model performed with very limited data.

IV. ANALYSIS PROCEDURE

A. MODEL ESTIMATES

1. Shape Parameter

Using the test data generated above, the shape parameter for the model was estimated at the end of each phase, i, using the AMSAA estimator:

$$\hat{\beta}_i = \frac{N_i}{N_i \ln T_i - \sum_{j=i}^{N_i} \ln X_j} ,$$

where

N_i = number of failures that occurred to the end of phase i,

T_i = total accumulated test time over all items to the end of phase i,

and X_j = total accumulated test time over all items when the j th failure occurs

with a small exception.[1]

2. Failure Rate

The model estimate of the failure rate at the end of the i th phase was computed in accordance with the AMSAA model as follows:

---

[1] It should be noted that the estimate of β can only be computed when $N_i \geq 1$. If $N_i = 1$, the failure must not occur as the last item of a phase since, in that case, $T_i = X_i$, thus making $\hat{\beta}$ an indeterminate form.

$$\hat{r}_i = \hat{\beta}_i \left(\frac{N_i}{T_i} \right) .$$

This resulted in a set of failure rate estimates that was then compared to the set of specified failure rates used to generate the test data.

B. EVALUATION CRITERIA

The manager using a reliability growth model is interested in two things, accuracy and variability.

1. Accuracy

Accuracy measures the ability of the model to track a reliability growth trend. The measure of accuracy used in evaluating the AMSAA model was the failure rate estimate error as a percentage of the actual failure rate.

This percentage error is defined as follows:

$$e_i = \frac{|\bar{\hat{r}}_i - r_i|}{r_i} \times 100 \quad ,$$

where $\bar{\hat{r}}_i$ = mean estimate of the failure rate for the i th phase[2]

and r_i = specified failure rate for the i the phase.

This measure of error was calculated at the end of each phase and used to trace the accuracy of the model over

---

[2] Sample may be less than the 100 replications simulated. See footnote 1, page 17.

all phases of each test case. This estimate error, as a percentage of the actual failure rate, can be found in the tabulated statistics for each Data Set of the tests contained in the appendices.

2. Variability

A manager, considering a reliability growth model for use in a program, will not only be concerned with the model's accuracy, but will be concerned with the variability of the estimates the model provides.

The simulation used for this evaluation was replicated 100 times. The mean estimates used to evaluate the tracking and measure the accuracy of the model only have value over the long run. A manager, however, is primarily interested in the one real application of the model. He is concerned with how well a model performs for a single replication and is thus ultimately concerned about the variability of the estimates he gets from the model in addition to its tracking accuracy.

The measure of variability used for this study was the standard deviation about the mean estimate of the failure rate, $\bar{\hat{r}}_i$,

$$S.D.(\hat{r}_i) = \sqrt{\frac{1}{K} \Sigma (\hat{r}_i - \bar{\hat{r}}_i)^2} ,$$

where K = number of replications that yielded estimates.

As with the failure rate percent error, the standard deviation of the failure rate estimate is contained in the tabulated statistics for each data set.

V. RESULTS

A. GENERAL DESCRIPTION

The results of the analysis are presented in the following manner. The output for each test is contained in a separate appendix to this paper. A data set is identified at the top of each page. This heading consists of the case number and the number of items for the data set. The output for each data set consists of two parts; the tabulated statistics and a performance plot. Figure 6 is a sample of the presentation of the results of a typical data set.

1. Tabulated Statistics

The input parameters, model estimates, measures of performance, and system status at the end of each phase of testing are tabulated for each data set. The values given are the average values over all replications for the data set. Figure 6 shows the format of the tabulated results. The following paragraphs describe each line of the format.

a. Input Parameters

(1) PHASE. This line indicates the phase of testing for the results listed below. Throughout the appendices, results for 6- and 16-phase growth patterns are presented. For 16-phase cases, the first 8 phases are tabulated above a row of asterisks. The same format is then repeated below the asterisks for phases 9 through 16.

```
                                             CASE    1

                                             10 ITEMS

PHASE                            1          2          3          4          5          6          7          8
-------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7020     0.4340     0.3200     0.2550     0.2130     0.1830     0.1610     0.1440
PLANNED  TEST  TIME         0.2315     0.3745     0.5079     0.6373     0.7630     0.8861     1.0094     1.1266
-------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             5.4898     0.6376     0.4502     0.3268     0.2581     0.2308     0.1957     0.1681
ESTIMATE  ERROR  AS         682.03      46.91      40.70      28.16      21.16      26.14      21.53      16.75
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       23.0502     0.4566     0.3009     0.1996     0.1228     0.1143     0.0903     0.0685
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         2.148      5.623     10.305     16.239     23.271     31.330     40.675     51.176
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         1.3300     2.8500     4.5300     5.9300     7.4700     9.1500    10.6200    12.0100
-------------------------------------------------------------------------------------------------------------------

.......................................................................................................................

PHASE                            9         10         11         12         13         14         15         16
-------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.1330     0.1160     0.1090     0.1010     0.0936     0.0876     0.0823     0.0776
PLANNED  TEST  TIME         1.2219     1.3773     1.4910     1.6091     1.7363     1.8552     1.9747     2.0943
-------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.1523     0.1385     0.1246     0.1127     0.1055     0.0977     0.0912     0.0858
ESTIMATE  ERROR  AS          14.48      17.24      14.29      11.61      12.76      11.58      10.85      10.54
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.0534     0.0447     0.0367     0.0332     0.0298     0.0265     0.0219     0.0207
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        62.421     75.054     88.887    103.821    119.802    136.857    155.152    174.540
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        13.5200    15.0600    16.4500    17.7900    19.3500    20.8200    22.3200    23.8000
-------------------------------------------------------------------------------------------------------------------
```

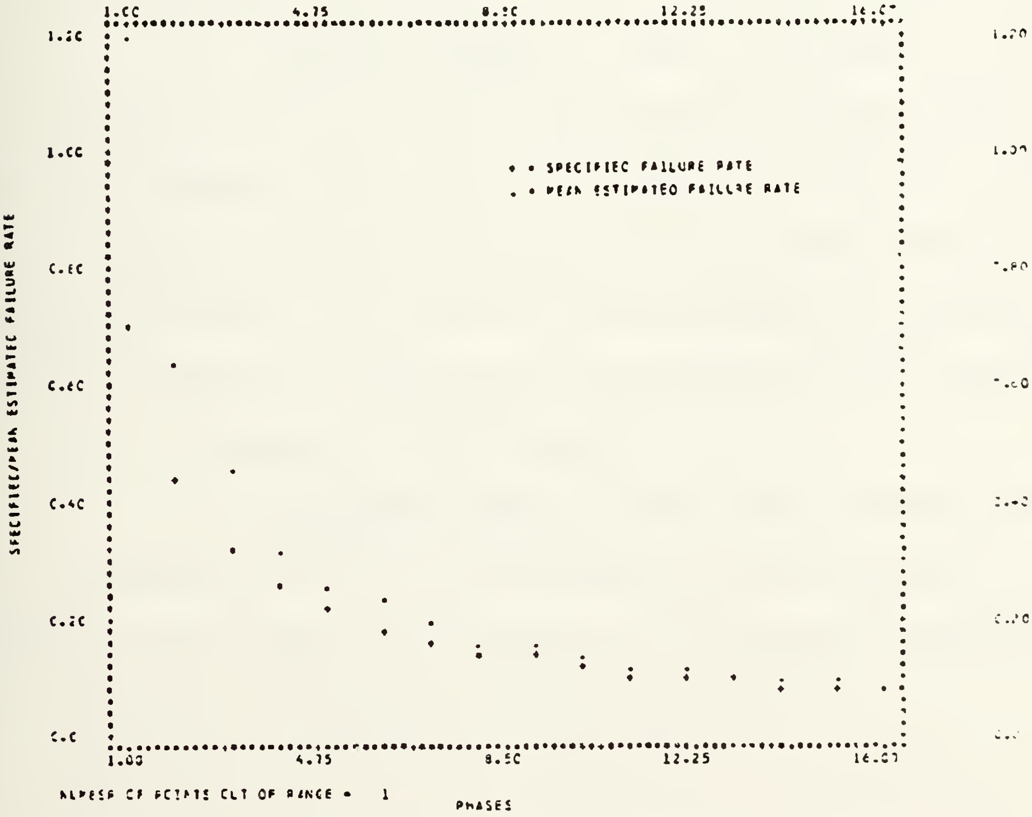


Figure 6. Format for Results of a Data Set

(2) ACTUAL FAILURE RATE. This row consists of the sequence of specified failure rates that defines the reliability growth curve for the test case given in the heading. In Figure 6, the specified failure rates for Phases 8 and 9 are 0.1440 and 0.1330 respectively.

(3) PLANNED TEST TIME. Here, the time to which each item was tested if it did not fail, is given. This number was based on the actual failure rate and the specified probability of survival for the test. This test time was the same for all items tested in a phase. For example, 10 items were tested in each of the 16 phases shown in Figure 6. Those items tested in Phase 8 were tested for 1.1286 time units or until failure.

b. Model Estimates

(1) MODEL ESTIMATE. Line 4 of Figure 6 contains the estimates of the failure rate provided by the AMSAA model (see Section IV-A) for each phase of testing. Referring to Figure 6, it can be seen that the model estimate of the failure rate at the end of the 8th Phase of testing was 0.1681 as compared to the actual failure rate of 0.1440.

c. Measures of Performance

(1) ESTIMATE ERROR. Here, the estimate error as a percentage of the actual failure rate, is given. Again, looking at the results for Phase 8, the percent error of 16.75 is found. This was computed as follows:

$$\frac{0.1681 - 0.1440}{0.1440} \times 100 = 16.74$$

The difference in the two percent errors is due to the extra accuracy carried by the computer.

(2) SAMPLE STD DEVIATION. The next line of entries is the standard deviation of the model estimate. This criteria is discussed in Section IV-B. The standard deviation of the model estimate for Phase 8 is 0.0685.

d. System Status

(1) CUMULATIVE TEST TIME. This row contains the total test time over all items as of the end of the indicated phase. At the end of the 8th Phase of testing, 51.176 time units of testing had been performed on the system.

(2) CUMULATIVE FAILURES. The final entry in the table is that of total failures on the system to the end of the phase. As illustrated by Figure 6, an average of 12.01 failures occurred over all replications. This means that, of the 80 items tested to the end of the 8th Phase, 12 failed.

2. Performance Plot

As an aid to evaluating the tracking accuracy of the model, the specified failure rate and the estimated failure rate are plotted for each phase of a test. Figure 6 contains an example of a typical plot.

All failure rates are plotted on a scale of 0 to 1.2. If an estimate is greater than 1.2, it is plotted at 1.2 and is noted as a point "out of range". More precise values of the points plotted can be obtained from the tabulated output above the plot.

The phases, for each failure rate plotted, are scaled on the horizontal axis. By referring to the CUMULATIVE TEST TIME row of the tabulated statistics above the plot, the amount of test time on the system, to the end of a phase, can be found.

For example, in Figure 6, the items tested had 51.176 time units of testing at the end of Phase 8 and 62.421 time units at the end of Phase 9. Thus test Phase 9 consisted of 11.245 time units of testing.

B. TEST 1

The results for Test 1 are given in Appendix A. Model estimates, made when cumulative test times on the system were less than 10 hours, had a high percentage error and large standard deviations. Testing more items per phase tended to provide better estimates earlier in the testing.

1. Non-increasing Failure Rates

As would be expected, the AMSAA model tracks growth patterns that approximate continuously decreasing curves (Case 1) better than those that have drastic step changes (Case 6). The model had a tendency to provide estimates which lag behind the actual value of the failure rate.

This is reflected in the increase in percentage error during the latter phases of testing. As can be seen in Case 4, several phases of constant failure rate will cause the model to lag behind even moderate changes in the failure rate.

2. Failure Rates that Increase

As can be seen in the performance plots of Cases 11 through 18, the AMSAA model has a tendency to smooth oscillations in the failure rate. This also seems to be due to the tendency of the model to provide estimates of the failure rate that lag the actual failure rate when the growth pattern makes large step changes. This characteristic can cause some large percentage errors and standard deviations in the later phases of testing when the failure rate increases for any reason.

C. TEST 2

Test 2 used planned test times generated for a probability of survival of .99. This resulted in far fewer failures during the testing which severely curtailed the model's ability to track a reliability growth pattern.

Appendix B contains the results for some representative cases. As in Test 1, a minimum number of test hours or failures is required for the model to make an accurate estimate. This requirement is not met when a high reliability system is being tested.

The results in Appendix B show a high percent error and a large standard deviation for the estimates made during the test.

D. MODIFICATIONS

As discussed above, the percentage error and the sample standard deviation of the model estimates were high during the early phases of testing and when failure rates increased. In an attempt to reduce this error, the AMSAA model was used in four modified test situations. All four tests used the point estimate of the failure rate

$$r_p = \frac{\text{number of failures during a phase}}{\text{total test time during a phase}} \; .$$

It should be noted that the number of failures and the test time used to compute the point estimate are not accumulated over all phases but are only for the current phase of testing.

The point estimate, r_p , was used for any phase where the cumulative test time on the system was less than 10 hours. Once the 10 hour threshold was exceeded, AMSAA model estimates were used. These estimates were made using all data from the beginning of testing if the failure rate was not considered to have increased. The four modified tests differed only in their handling of increasing failure rates.

1. Estimating Slope

In order to determine whether the trend of failure rates was increasing, the slope of the trend was estimated. Two methods were used:

a. 2-Point Estimate of Slope

The slope was estimated using the point estimate, r_p, for the current phase and the last estimate, $\hat{r}_{i-1}$, which may have been from the model or a point estimate.

$$\text{Thus} \quad \text{SLOPE} = r_p - \hat{r}_{i-1} .$$

b. 3-Point Estimate of Slope

This method of estimating slope was used to reduce the change that the estimated slope would be affected by a randomly high point estimate. The slope was estimated using the point estimate, r_p, for the current phase and the last two estimates $\hat{r}_{i-1}$ and $\hat{r}_{i-2}$. The slope estimated consisted of two parts:

$$\hat{r}_{i-1} - \hat{r}_{i-2} \quad \text{and} \quad r_p - \hat{r}_{i-1} .$$

For the estimate of the slope to be considered increasing, both parts had to be determined to be increasing.

2. Determining Increasing Slope

Two methods of determining when an estimate of slope could be considered increasing were used. The estimates of slope described above were tested in one of the

following ways for each of the modified tests.

$$\text{SLOPE} \geq .07$$

$$\text{SLOPE} \geq .2\hat{r}_{i-1}$$

3. Modified Tests

Figure 7 shows the composition of each of the four modified tests.

	SLOPE $\geq .07$	SLOPE $\geq .2r_{i-1}$
2-Point Slope Estimate	MOD1 $r_p - r_{i-1} \geq .07$	MOD2 $r_p - r_{i-1} \geq .2r_{i-1}$
3-Point Slope Estimate	MOD3 $r_{i-1} - r_{i-2} \geq .07$ and $r_p - r_{i-1} \geq .07$	MOD4 $r_{i-1} - r_{i-2} \geq .2r_{i-2}$ and $r_p - r_{i-1} \geq .2r_{i-1}$

Figure 7. Composition of the Modified Tests

The results of the modified tests are presented in the appendices as follows:

TEST	APPENDIX
MOD1	C
MOD2	D
MOD3	E
MOD4	F

Cases 4, 13, 15, and 18 are presented for each test.

APPENDIX A

Results of Test 1

The results of Test 1 for Cases 1 through 18 are contained in this appendix. Each case consists of three data sets, one each for 5, 10, and 20 items. The results are presented in two parts; the tabulated statistics and a performance plot. The elements of the tabulated statistics are described below. For 16-phase cases, the first eight phases are presented above the asterisks and the last eight are shown below.

1. Input Parameters

   a. PHASE

   This line indicates the phase of testing for which the elements listed below apply. All statistics are as of the end of the indicated phase.

   b. ACTUAL FAILURE RATE

   This line contains the failure rate specified for the indicated phase. This failure rate was used to generate the exponential failure times used as data for the model.

   c. PLANNED TEST TIME

   This is the test time to which each item was tested if failure did not occur earlier. For Test 1, the planned test times were generated so that the probability of survival was .85.

2. Model Estimates

a. MODEL ESTIMATE

This is the estimate of the failure rate provided by the model for the test phase indicated (See Section IV-A).

3. Measures of Performance

a. ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE

These entries were computed as a measure of accuracy to be used for evaluating the tracking accuracy of the AMSAA model (See Section VI-B).

b. SAMPLE STD DEVIATION

These values were computed as a measure of variability for the estimate error (See Section IV-B).

4. System Status

a. CUMULATIVE TEST TIME

The times listed are the total test time accumulated over all phases of testing to the end of the indicated phase.

b. CUMULATIVE FAILURES

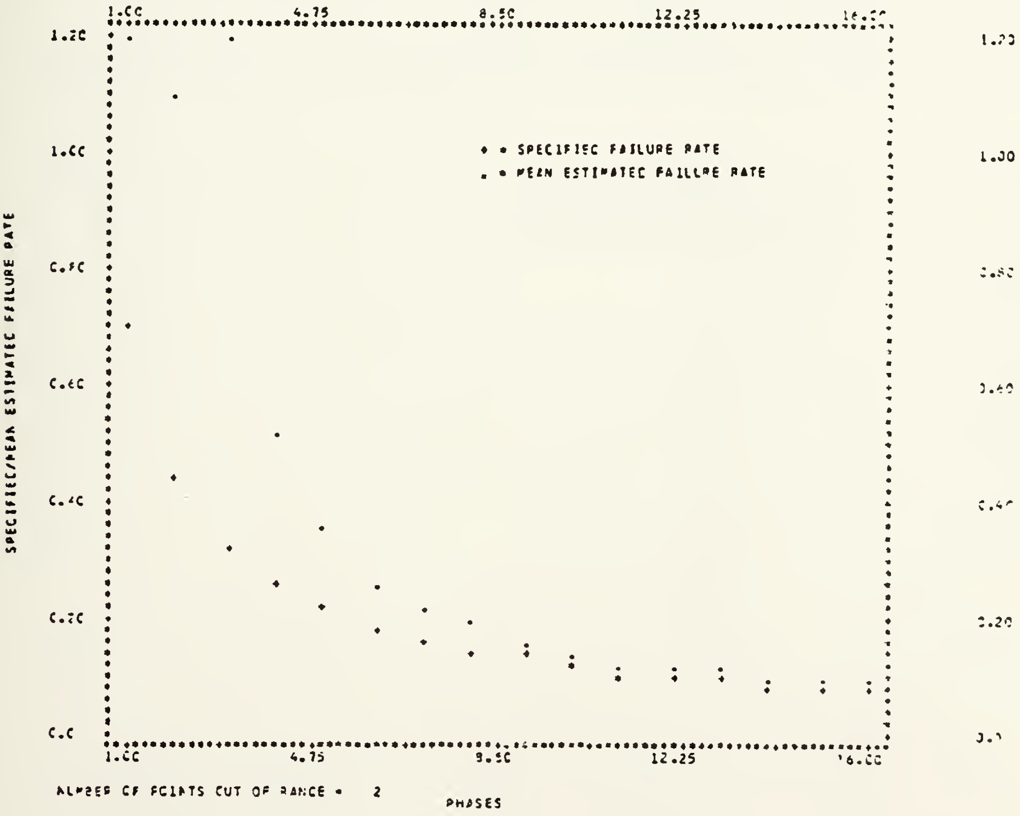
These entries are the total failuares over all items tested for all phases through the indicated phase.

CASE 1

5 ITEMS

```
PHASE                        1        2        3        4        5        6        7        8
----------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.7020   0.4340   0.3200   0.2550   0.2130   0.1830   0.1610   0.1440
PLANNED  TEST  TIME     0.2315   0.3745   0.5079   0.6373   0.7630   0.8681   1.0094   1.1286
----------------------------------------------------------------------------------------------
MODEL  ESTIMATE         2.3197   1.1099   1.7535   0.5154   0.3615   0.2551   0.2240   0.1935
ESTIMATE  ERROR  AS     230.44   155.73   447.98   102.12    69.72    39.42    39.14    34.35
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    2.1070   1.2748   7.1630   0.5357   0.2906   0.1362   0.1182   0.1073
----------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     1.081    2.822    5.140    8.033   11.513   15.614   20.248   25.487
----------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     0.5900   1.3100   2.0500   2.9200   3.7700   4.5000   5.2400   5.9600
----------------------------------------------------------------------------------------------
```

```
PHASE                        9       10       11       12       13       14       15       16
----------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.1330   0.1180   0.1090   0.1010   0.0936   0.0876   0.0823   0.0776
PLANNED  TEST  TIME     1.2219   1.3773   1.4910   1.6091   1.7363   1.8552   1.9747   2.0943
----------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.1593   0.1390   0.1294   0.1178   0.1112   0.1052   0.0993   0.0908
ESTIMATE  ERROR  AS      19.78    17.79    18.71    16.59    18.83    20.09    20.63    17.04
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.0778   0.0728   0.0632   0.0557   0.0521   0.0464   0.0457   0.0364
----------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME    31.248   37.694   44.478   51.958   59.839   68.251   77.256   86.556
----------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     6.5900   7.1900   8.0000   8.7000   9.5100  10.3200  11.1200  11.8000
----------------------------------------------------------------------------------------------
```

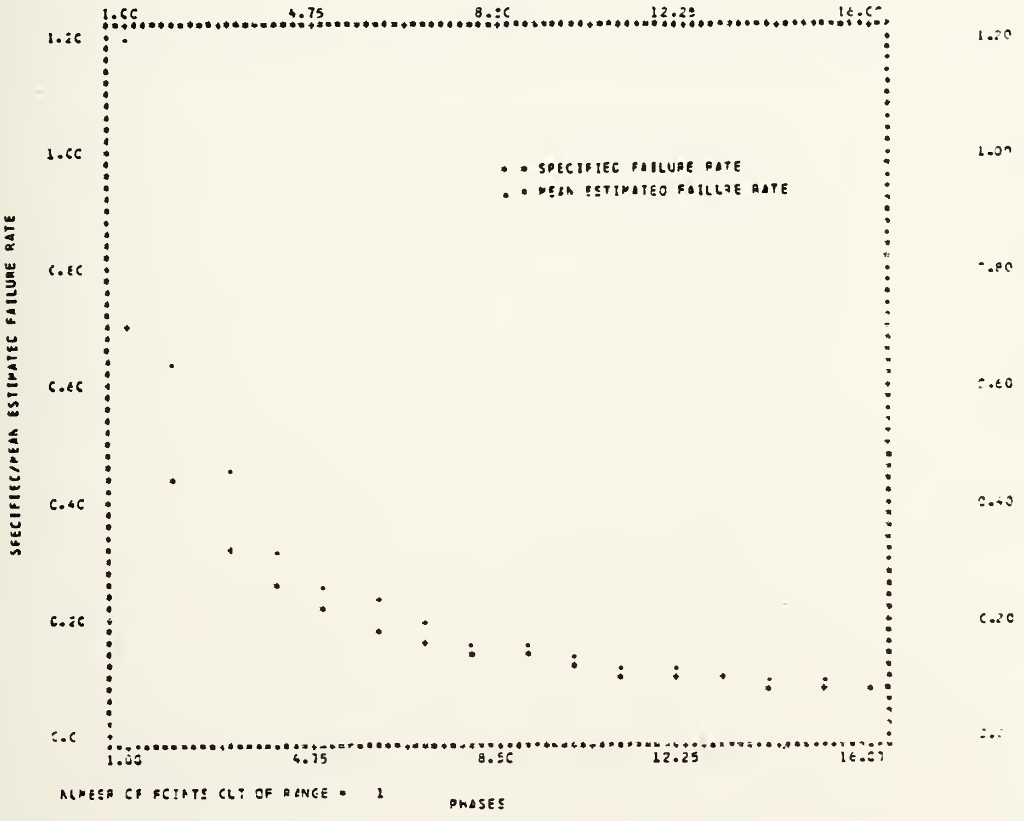


CASE 1

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7020	0.4340	0.3200	0.2550	0.2130	0.1830	0.1610	0.1440
PLANNED TEST TIME	0.2215	0.3745	0.5079	0.6373	0.7630	0.8881	1.0054	1.1266
MODEL ESTIMATE	5.4898	0.6376	0.4502	0.3268	0.2581	0.2308	0.1957	0.1681
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	682.03	46.91	40.70	28.16	21.16	26.14	21.53	16.75
SAMPLE STD DEVIATION	23.0532	0.4566	0.3009	0.1996	0.1228	0.1143	0.0903	0.0685
CUMULATIVE TEST TIME	2.148	5.623	10.309	16.239	23.271	31.230	40.675	51.176
CUMULATIVE FAILURES	1.3300	2.8500	4.5300	5.9300	7.4700	9.1500	10.6200	12.0100

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.1330	0.1160	0.1090	0.1010	0.0936	0.0876	0.0823	0.0776
PLANNED TEST TIME	1.2219	1.3773	1.4910	1.6091	1.7363	1.8552	1.9747	2.0543
MODEL ESTIMATE	0.1523	0.1385	0.1246	0.1127	0.1055	0.0977	0.0912	0.0858
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	14.48	17.24	14.29	11.61	12.76	11.58	10.85	10.54
SAMPLE STD DEVIATION	0.0534	0.0447	0.0367	0.0332	0.0298	0.0265	0.0219	0.0207
CUMULATIVE TEST TIME	62.421	75.054	88.867	103.821	119.802	136.857	155.152	174.540
CUMULATIVE FAILURES	13.5200	15.0600	16.4500	17.7900	19.3500	20.8200	22.3200	23.8000



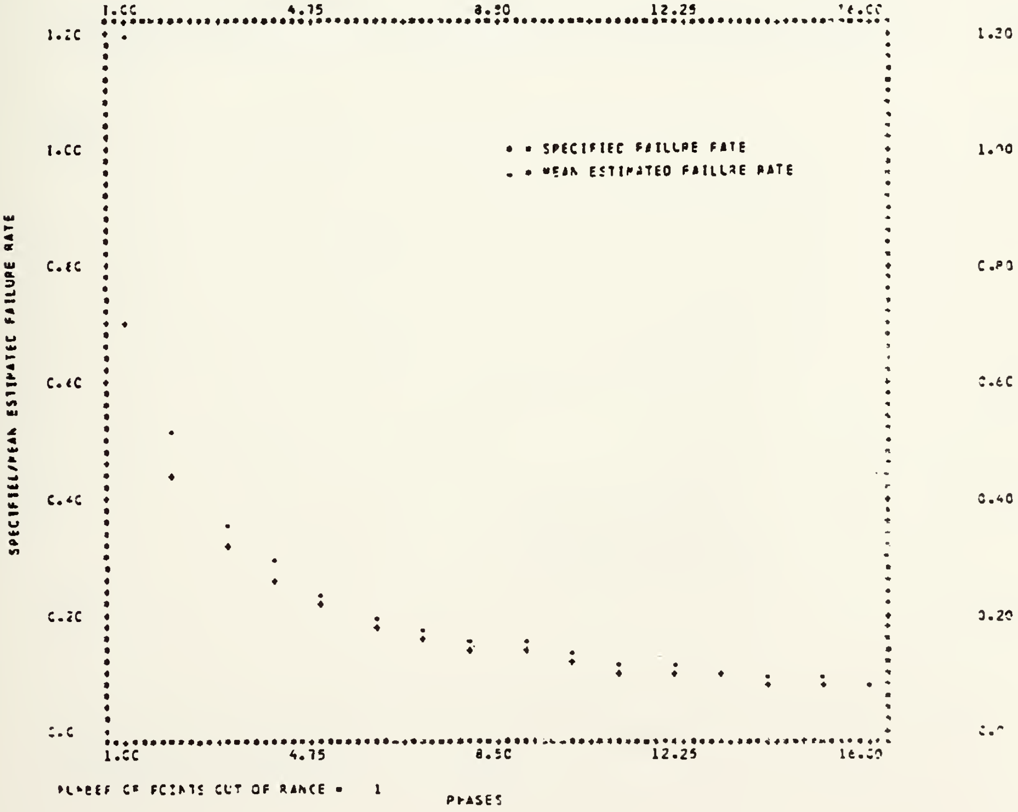
```
                                   CASE  1

                                   20 ITEMS

PHASE                        1        2        3        4        5        6        7        8
--------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.7020   0.4340   0.3200   0.2550   0.2130   0.1830   0.1610   0.1440
PLANNED  TEST  TIME     0.2315   0.3745   0.5079   0.6373   0.7630   0.8881   1.0094   1.1266
--------------------------------------------------------------------------------------------
MODEL  ESTIMATE         1.2651   0.5279   0.3657   0.2902   0.2438   0.2063   0.1839   0.1631
ESTIMATE  ERROR  AS      80.22    21.64    14.27    13.82    14.47    12.72    14.21    13.24
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    2.0237   0.3178   0.1490   0.1098   0.0852   0.0654   0.0591   0.0451
--------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     4.268   11.149   20.483   32.164   46.215   62.668   81.203  101.970
--------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     3.0200   6.0600   9.0400  11.9900  15.0800  18.0400  21.2300  24.3000
--------------------------------------------------------------------------------------------

.............................................................................................

PHASE                        9       10       11       12       13       14       15       16
--------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.1330   0.1180   0.1090   0.1010   0.0936   0.0876   0.0823   0.0776
PLANNED  TEST  TIME     1.2219   1.3773   1.4910   1.6091   1.7363   1.8552   1.9747   2.0943
--------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.1504   0.1383   0.1228   0.1136   0.1058   0.0993   0.0922   0.0882
ESTIMATE  ERROR  AS      13.08    17.17    12.69    12.45    13.05    13.39    11.97    13.64
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.0362   0.0309   0.0253   0.0229   0.0208   0.0186   0.0165   0.0146
--------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME   124.427  149.585  177.291  206.990  238.784  272.769  309.339  347.506
--------------------------------------------------------------------------------------------
CUMULATIVE FAILURES    27.6100  30.8600  33.5300  36.6200  39.7000  42.6700  45.7600  49.2200
--------------------------------------------------------------------------------------------
```



NUMBER OF POINTS OUT OF RANGE =   1

```
                                         CASE  2

                                         5 STEPS

PHASE                        1        2        3        4        5        6        7        8
--------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000   0.7000   0.7000   0.7000   0.7000   0.7000   0.7000   0.7000
PLANNED  TEST  TIME       0.2322   0.2322   0.2322   0.2322   0.2322   0.2322   0.2322   0.2322
--------------------------------------------------------------------------------------------
MODEL  ESTIMATE           2.5820   3.6035   2.0250   1.0389   0.9719   0.8213   0.8325   0.8381
ESTIMATE  ERROR  AS       268.86   414.78   189.29    48.41    38.84    17.33    18.93    19.73
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      2.5461  13.3555   6.3476   0.0193   0.8982   0.5571   0.5512   0.4565
--------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.063    2.129    3.198    4.280    5.360    6.437    7.497    8.560
--------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.7300   1.5400   2.3400   3.0300   3.7400   4.3300   5.2200   6.0200
--------------------------------------------------------------------------------------------

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PHASE                        9       10       11       12       13       14       15       16
--------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000   0.7000   0.7000   0.7000   0.7000   0.7000   0.7000   0.7000
PLANNED  TEST  TIME       0.2322   0.2322   0.2322   0.2322   0.2322   0.2322   0.2322   0.2322
--------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.8858   0.8628   0.8081   0.7941   0.7958   0.7798   0.7532   0.7324
ESTIMATE  ERROR  AS        26.54    24.12    15.44    13.44    13.68    11.39     7.60     4.63
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.5860   0.6019   0.4465   0.3572   0.3992   0.3547   0.3149   0.2960
--------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       9.630   10.701   11.781   12.854   13.916   14.988   16.072   17.152
--------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       6.8400   7.5600   8.2100   8.9500   9.7500  10.5500  11.2100  11.8400
--------------------------------------------------------------------------------------------
```

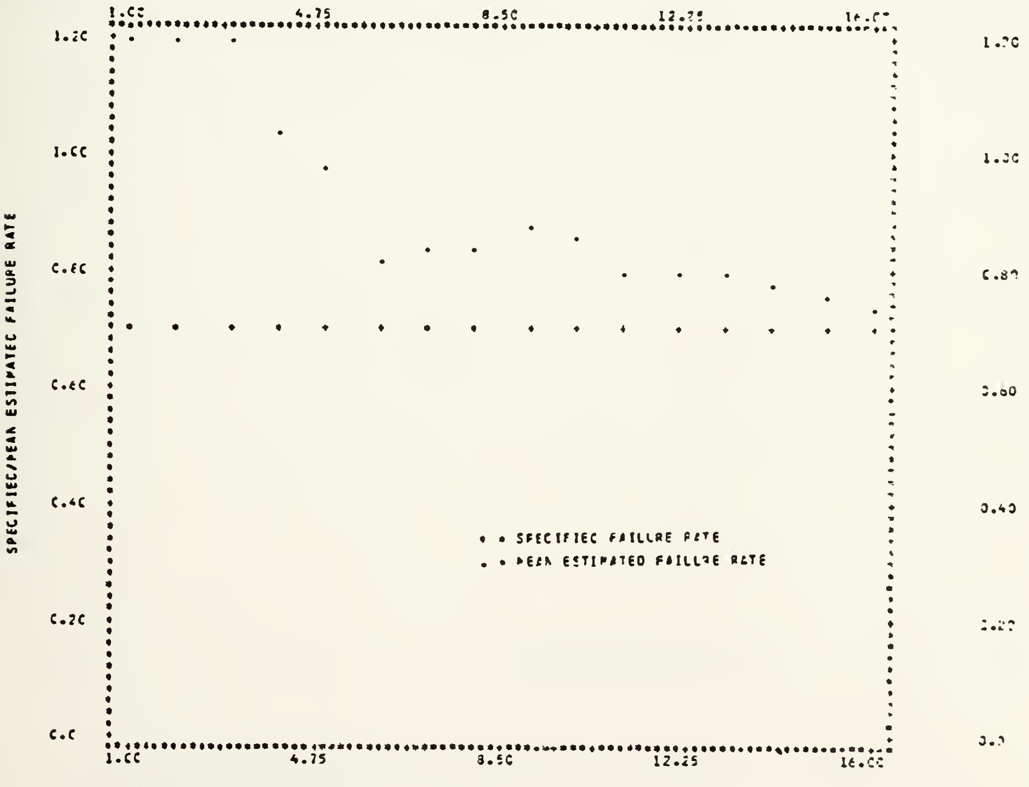

NUMBER OF POINTS OUT OF RANGE = 3

PHASES

```
                                   CASE  2

                                   10 ITEMS

 PHASE                         1         2         3         4         5         6         7         8
 ---------------------------------------------------------------------------------------------------------
 ACTUAL FAILURE RATE       0.7000    0.7000    0.7000    0.7000    0.7000    0.7000    0.7000    0.7000
 PLANNED  TEST  TIME       0.2322    0.2322    0.2322    0.2322    0.2322    0.2322    0.2322    0.2322
 ---------------------------------------------------------------------------------------------------------
 MODEL  ESTIMATE           2.0018    1.3248    0.9434    0.8588    0.8760    0.8474    0.8013    0.8192
 ESTIMATE  ERROR  AS       185.97     89.26     34.77     22.69     25.14     21.06     14.46     16.38
 PERCENTAGE OF ACTUAL
 FAILURE RATE
 SAMPLE STD DEVIATION      2.6203    1.1657    0.7177    0.5045    0.4716    0.3547    0.3234    0.3188
 ---------------------------------------------------------------------------------------------------------
 CUMULATIVE TEST TIME       2.159     4.285     6.451     8.597    10.720    12.877    15.016    17.148
 ---------------------------------------------------------------------------------------------------------
 CUMULATIVE FAILURES       1.3600    3.0600    4.3700    5.6500    7.5800    9.0700   10.5600   12.2600
 ---------------------------------------------------------------------------------------------------------

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 PHASE                         9        10        11        12        13        14        15        16
 ---------------------------------------------------------------------------------------------------------
 ACTUAL FAILURE RATE       0.7000    0.7000    0.7000    0.7000    0.7000    0.7000    0.7000    0.7000
 PLANNED  TEST  TIME       0.2322    0.2322    0.2322    0.2322    0.2322    0.2322    0.2322    0.2322
 ---------------------------------------------------------------------------------------------------------
 MODEL  ESTIMATE           0.8184    0.7970    0.7926    0.7919    0.7857    0.7816    0.7787    0.7747
 ESTIMATE  ERROR  AS        16.91     13.86     13.23     13.12     12.24     11.66     11.24     10.67
 PERCENTAGE OF ACTUAL
 FAILURE RATE
 SAMPLE STD DEVIATION      0.3175    0.2945    0.2765    0.2506    0.2372    0.2349    0.2367    0.2270
 ---------------------------------------------------------------------------------------------------------
 CUMULATIVE TEST TIME      19.274    21.417    23.553    25.680    27.822    29.960    32.095    34.230
 ---------------------------------------------------------------------------------------------------------
 CUMULATIVE FAILURES      13.8600   15.3100   16.9100   18.5200   20.0600   21.5900   23.1300   24.6400
 ---------------------------------------------------------------------------------------------------------
```

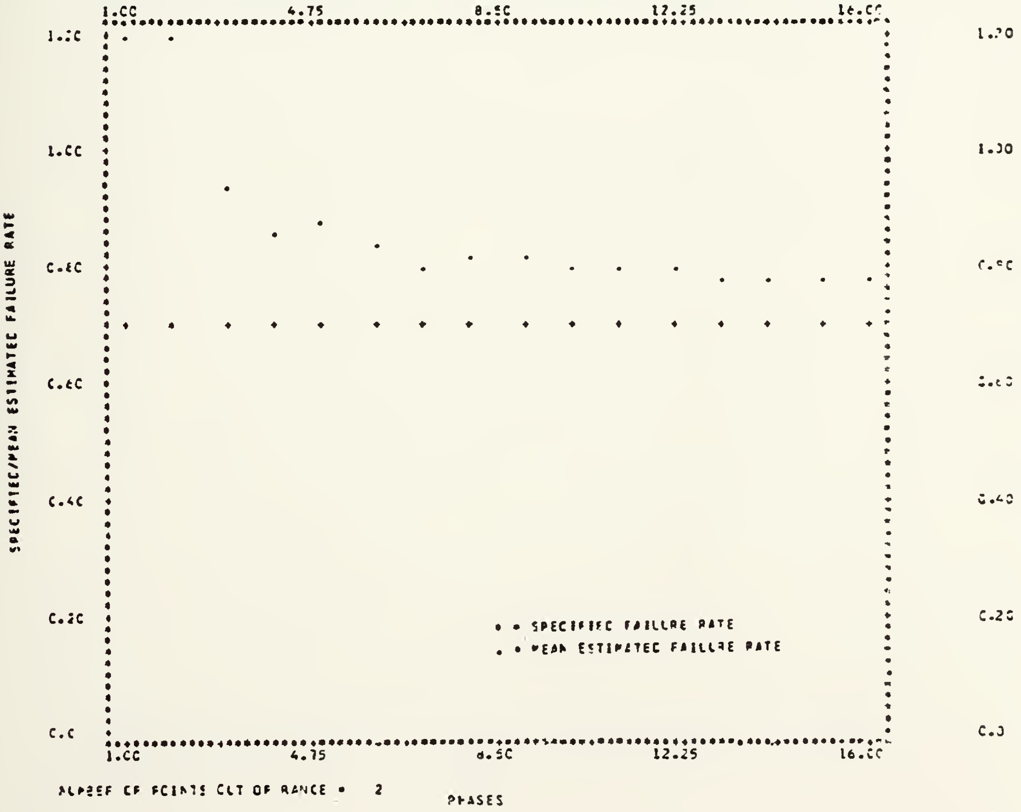

```
                                        CASE   3

                                        10 ITEMS

PHASE                              1          2          3          4          5          6          7          8
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE           0.7000     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME           0.2322     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE               1.6357     0.0818     0.0607     0.0541     0.0482     0.0468     0.0429     0.0444
ESTIMATE  ERROR  AS           133.66      63.55      21.37       8.20       3.50       6.31      14.12      11.17
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION          1.5047     0.0804     0.0518     0.0457     0.0265     0.0253     0.0197     0.0192
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME           2.157     31.678     61.491     91.432    121.048    150.665    181.030    210.614
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES           1.3400     3.1500     4.8300     6.4000     7.9500     9.9200    10.8300    12.4800
-----------------------------------------------------------------------------------------------------------------

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PHASE                              9         10         11         12         13         14         15         16
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE           0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME           3.2504     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE               0.0441     0.0438     0.0430     0.0432     0.0436     0.0450     0.0456     0.0457
ESTIMATE  ERROR  AS            11.80      12.42      14.05      13.50      12.86      10.06       8.88       8.71
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION          0.0201     0.0177     0.0177     0.0174     0.0177     0.0194     0.0193     0.0192
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         240.918    270.784    301.220    331.226    360.931    390.671    420.553    450.738
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          13.9200    15.4400    16.7500    18.2800    19.8300    21.5300    23.1700    24.5500
-----------------------------------------------------------------------------------------------------------------
```
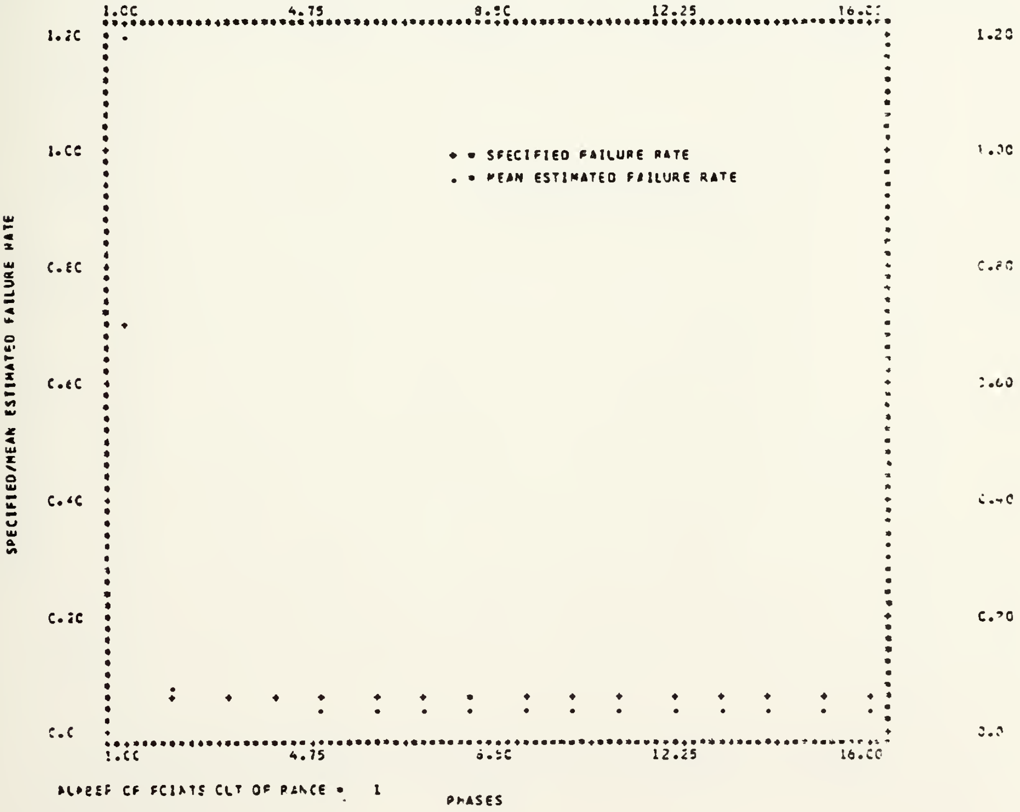
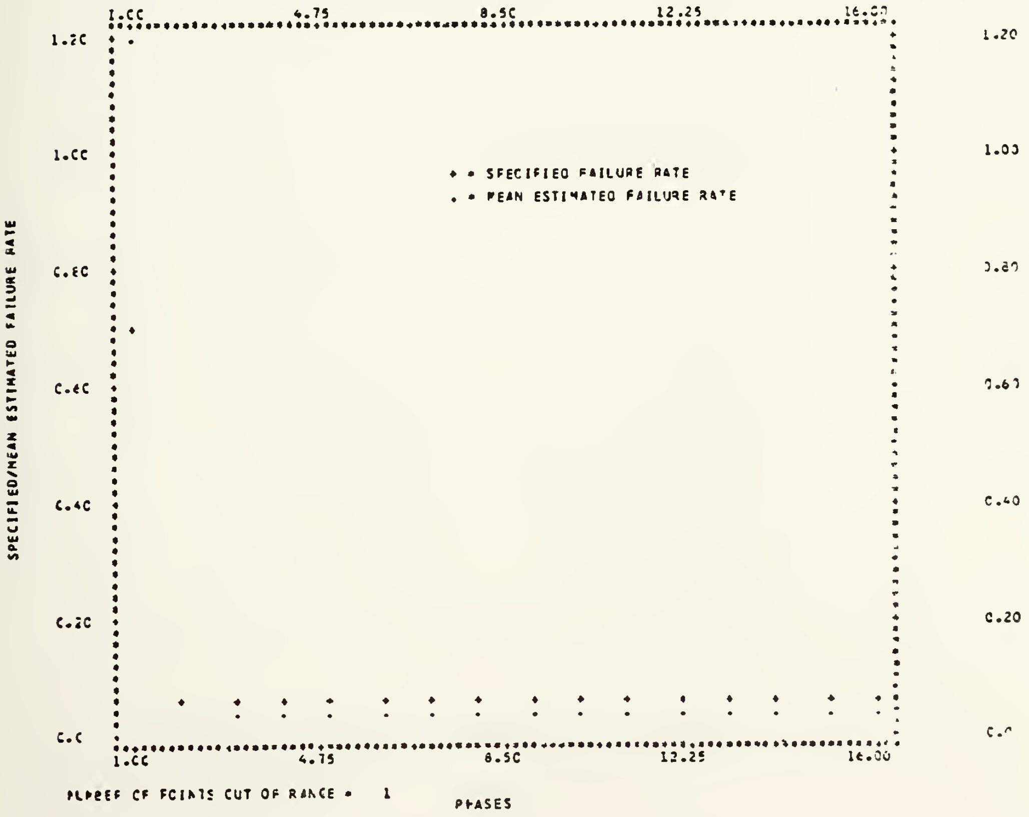



CASE 3

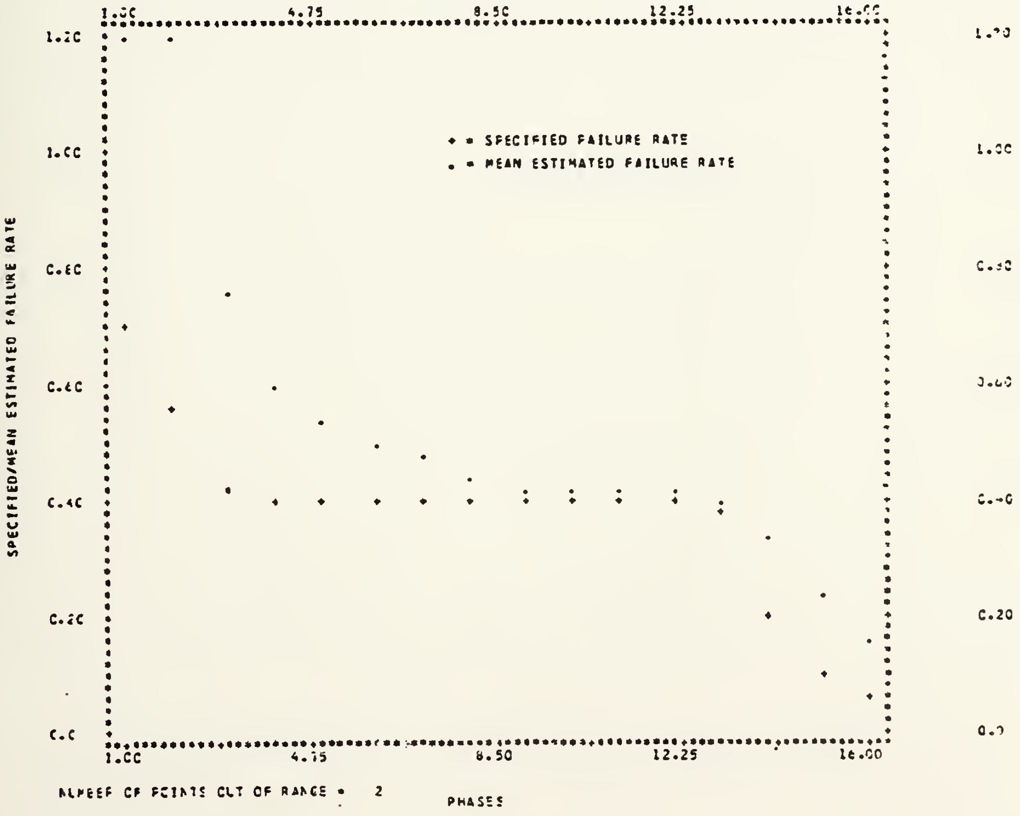
20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2322	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	1.2922	0.0545	0.0395	0.0392	0.0401	0.0400	0.0400	0.0408
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	84.61	9.08	21.05	21.58	19.81	20.06	20.09	18.48
SAMPLE STD DEVIATION	1.8262	0.0438	0.0176	0.0142	0.0169	0.0241	0.0129	0.0221
CUMULATIVE TEST TIME	4.223	64.115	124.571	184.251	244.255	304.437	364.456	424.223
CUMULATIVE FAILURES	2.7500	5.8100	8.6700	11.8000	14.9400	17.9100	20.9100	24.0900

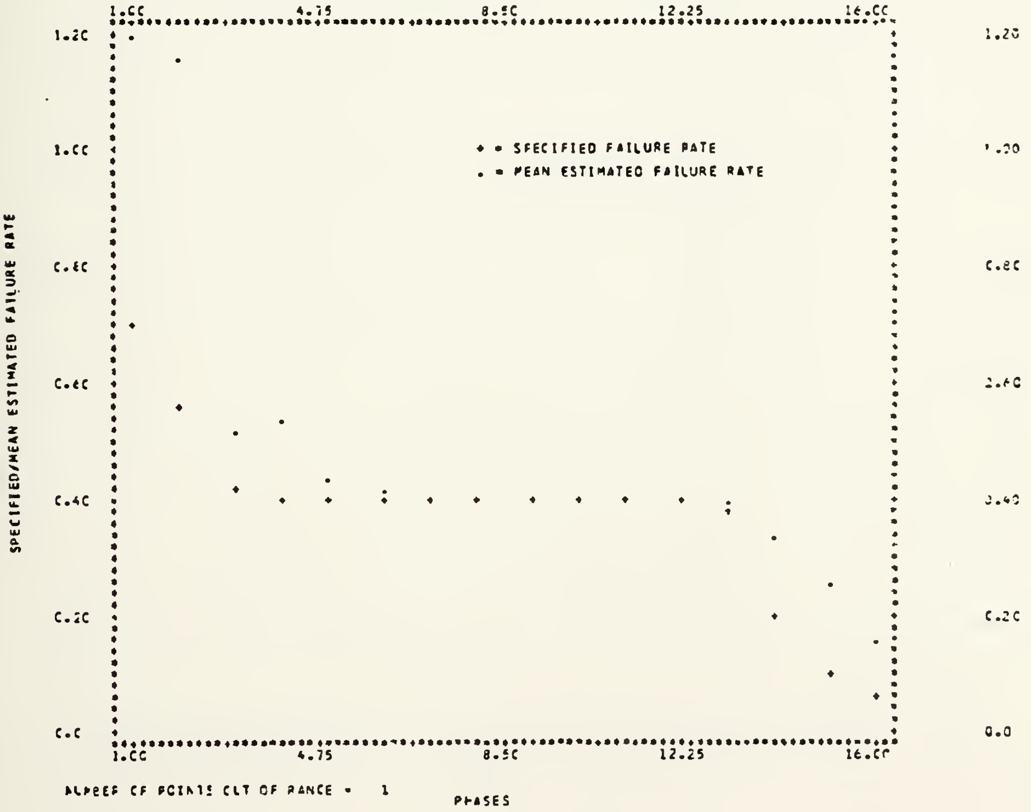
PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.0406	0.0405	0.0413	0.0415	0.0425	0.0425	0.0423	0.0425
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	18.84	18.90	17.39	17.06	15.04	15.04	15.47	15.06
SAMPLE STD DEVIATION	0.0110	0.0108	0.0105	0.0103	0.0111	0.0110	0.0108	0.0112
CUMULATIVE TEST TIME	484.639	545.173	604.765	665.234	724.717	784.785	844.900	905.239
CUMULATIVE FAILURES	26.9400	29.8000	32.9300	35.8900	39.1000	41.9900	44.7300	47.6600



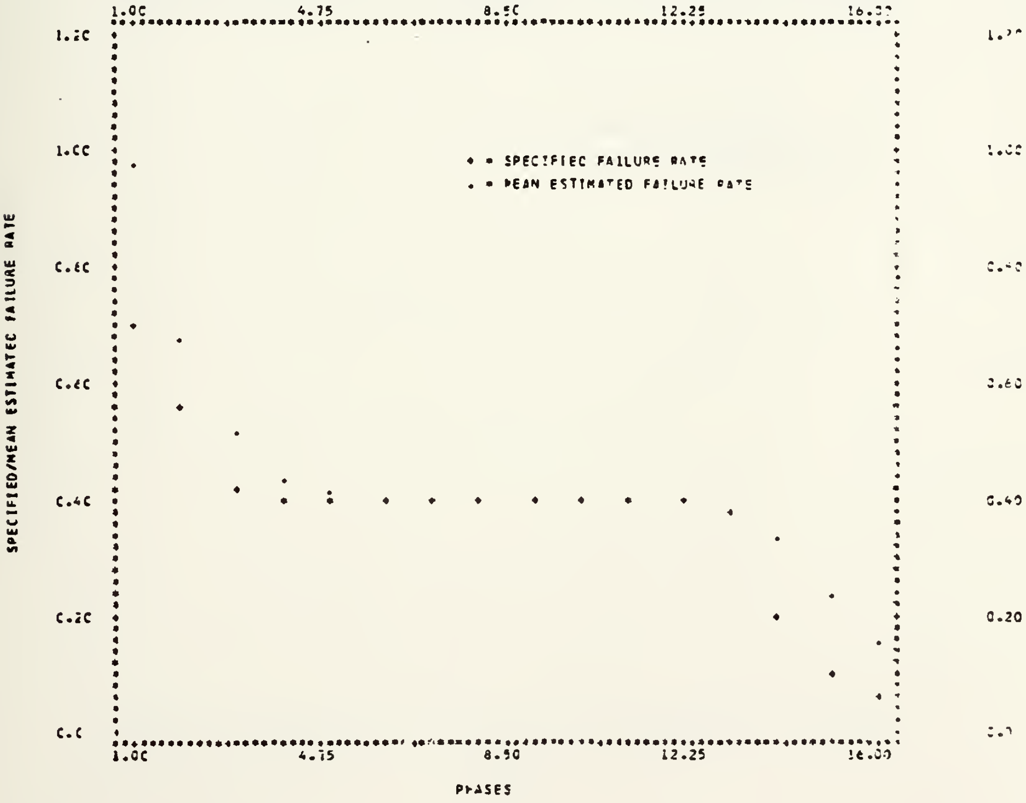
```
                                        CASE   4

                                         5 ITEMS

PHASE                          1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.5500    0.4250    0.4050    0.4000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2322    0.2955    0.3824    0.4013    0.4063    0.4063    0.4063    0.4063
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           3.4375    1.8021    0.7642    0.5960    0.5432    0.4942    0.4829    0.4354
ESTIMATE  ERROR  AS       391.08    227.66     79.81     47.15     35.83     23.56     20.73      8.86
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      6.9796    2.3862    0.7915    0.4386    0.4800    0.4704    0.3864    0.2626
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.074     2.418     4.202     6.049     7.942     9.843    11.657    13.580
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.6400    1.5100    2.1100    2.9100    3.6300    4.2700    5.0700    5.7700
------------------------------------------------------------------------------------------------------


..............................................................................................................


PHASE                          9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.4000    0.4000    0.3750    0.2000    0.1000    0.0500
PLANNED  TEST  TIME       0.4063    0.4063    0.4063    0.4063    0.4334    0.8126    1.6252    3.2504
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.4266    0.4259    0.4199    0.4204    0.4005    0.3396    0.2499    0.1550
ESTIMATE  ERROR  AS         6.65      6.49      4.97      5.11      6.79     69.81    149.89    209.98
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.2152    0.1963    0.1891    0.1981    0.2027    0.1483    0.0977    0.0567
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      15.442    17.319    19.186    21.049    23.079    26.860    34.326    49.304
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       6.5800    7.3600    8.0700    8.7800    9.3800   10.0800   10.8900   11.6400
------------------------------------------------------------------------------------------------------
```



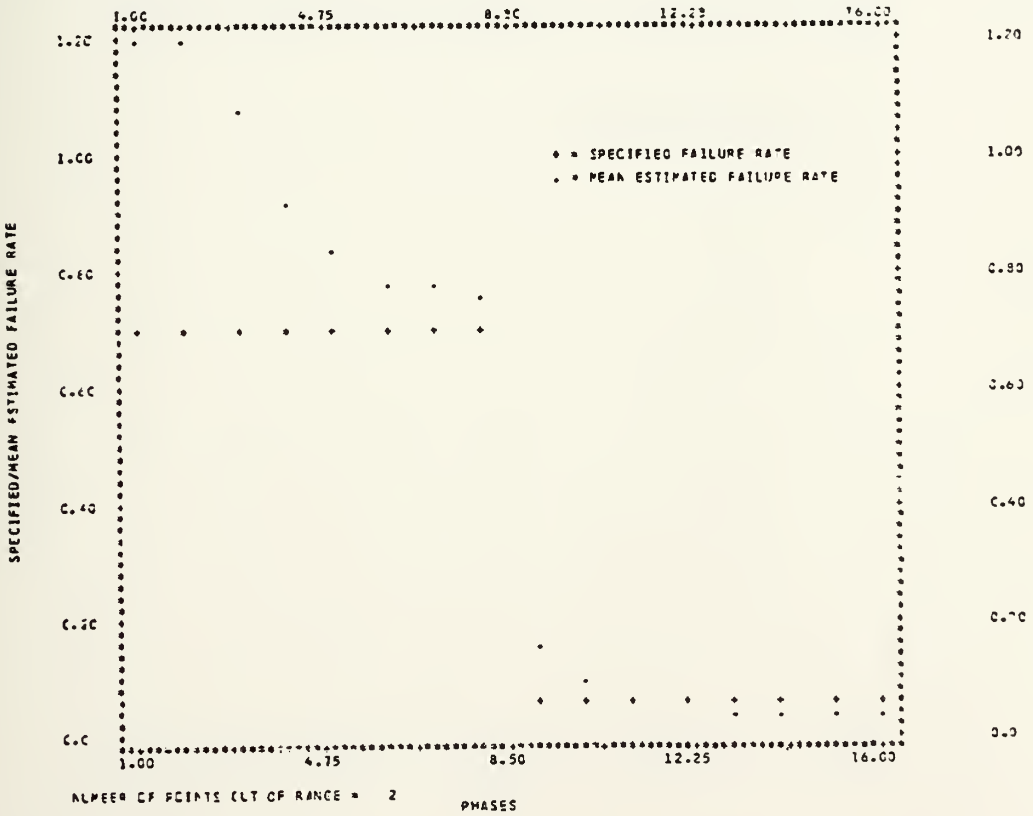
```
                                          CASE   4

                                         10 ITEMS

PHASE                        1         2         3         4         5         6         7         8
-------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.5500    0.4250    0.4050    0.4000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2322    0.2955    0.3824    0.4013    0.4063    0.4063    0.4063    0.4063
-------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           2.9592    1.1648    0.5144    0.5460    0.4436    0.4138    0.3994    0.3957
ESTIMATE  ERROR  AS       322.75    111.77     21.03     34.81     10.90      3.45      0.16      1.08
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      7.4930    3.2214    0.3913    0.5357    0.2234    0.2165    0.1741    0.1626
-------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.136     4.887     8.462    12.133    15.862    19.622    23.410    27.195
-------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.5400    2.9400    4.1400    5.8600    7.3100    8.6400   10.1000   11.5300
-------------------------------------------------------------------------------------------------------

**********************************************************************************************************

PHASE                        9        10        11        12        13        14        15        16
-------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.4000    0.4000    0.3750    0.2000    0.1000    0.0500
PLANNED  TEST  TIME       0.4063    0.4063    0.4063    0.4063    0.4334    0.6126    1.6257    3.2504
-------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.3945    0.3927    0.3932    0.3948    0.3931    0.3440    0.2548    0.1571
ESTIMATE  ERROR  AS         1.37      1.84      1.70      1.31      4.84     72.02    154.81    214.20
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.1511    0.1524    0.1344    0.1347    0.1179    0.0896    0.0698    0.0332
-------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      30.943    34.723    38.459    42.187    46.178    53.627    66.565    98.321
-------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      13.0700   14.4500   16.0100   17.5700   19.1600   20.8000   22.3600   23.9320
-------------------------------------------------------------------------------------------------------
```



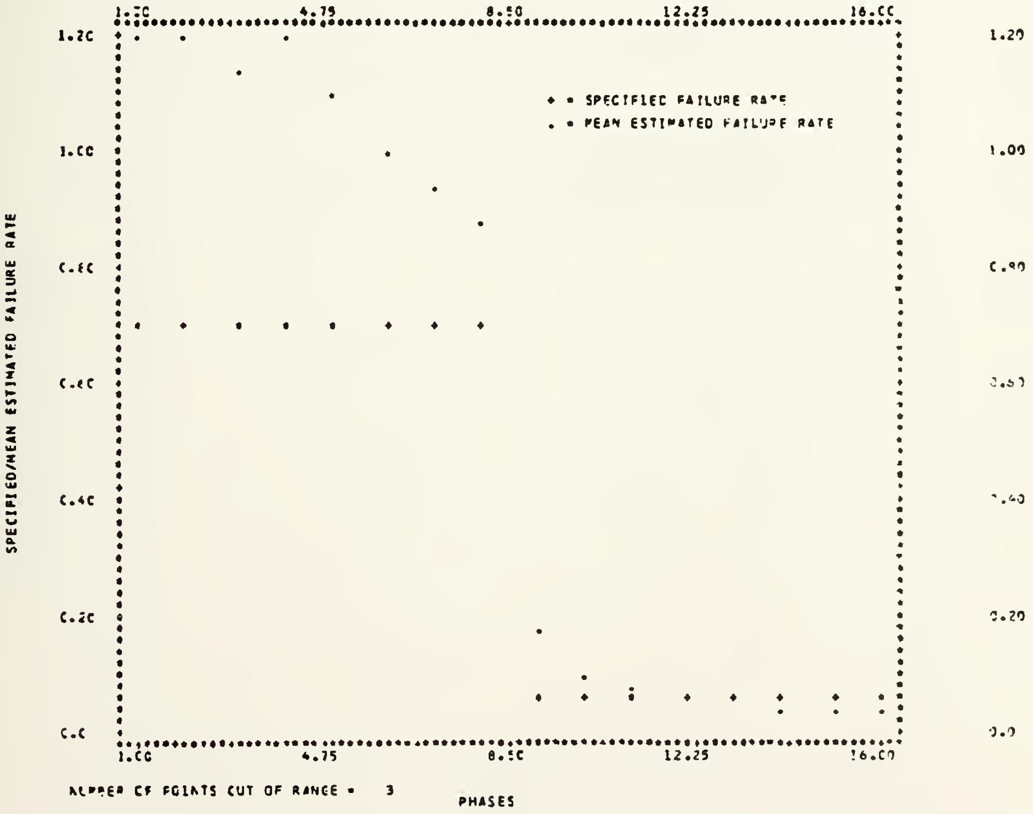
```
                                              CASE   4

                                              20 ITEMS

PHASE                              1          2          3          4          5          6          7          8
------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE           0.7000     0.5500     0.4250     0.4050     0.4000     0.4000     0.4000     0.4000
PLANNED  TEST  TIME           0.2322     0.2555     0.3824     0.4013     0.4063     0.4063     0.4063     0.4063
------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE               0.9732     0.6785     0.5168     0.4366     0.4171     0.4053     0.4017     0.4060
ESTIMATE  ERROR  AS            39.02      23.37      21.59       7.80       4.28       1.32       0.43       1.50
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION          0.7062     0.4160     0.2553     0.1704     0.1717     0.1370     0.1267     0.1190
------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME           4.323      9.798     16.874     24.303     31.758     39.227     46.759     54.188
------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES           2.9500     5.9600     8.8700    11.7100    14.7100    17.7600    20.8500    24.0300
------------------------------------------------------------------------------------------------------------------

**********************************************************************************************************************

PHASE                              9         10         11         12         13         14         15         16
------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE           0.4000     0.4000     0.4000     0.4000     0.3750     0.2000     0.1000     0.0500
PLANNED  TEST  TIME           0.4063     0.4063     0.4063     0.4063     0.4334     0.8126     1.6252     3.7504
------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE               0.3999     0.4033     0.3981     0.3941     0.3861     0.3366     0.2442     0.1579
ESTIMATE  ERROR  AS             0.03       0.83       0.48       1.49       2.97      68.29     144.21     221.76
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION          0.1101     0.1160     0.1023     0.0970     0.0918     0.0766     0.0454     0.0272
------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME          61.676     69.123     76.672     84.172     92.154    107.194    137.320    197.422
------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          27.0400    30.2200    33.2300    36.1700    39.0600    42.0600    44.8000    47.8000
------------------------------------------------------------------------------------------------------------------
```



```
                                              CASE   5

                                              10 ITEMS

PHASE                          1          2          3          4          5          6          7          8
----------------------------------------------------------------------------------------------------------------

ACTUAL FAILURE RATE       0.7000     0.7000     0.7000     0.7000     0.7000     0.7000     0.7000     0.7000
PLANNED  TEST  TIME       0.2322     0.2322     0.2322     0.2322     0.2322     0.2322     0.2322     0.2322
----------------------------------------------------------------------------------------------------------------

MODEL  ESTIMATE           1.4870     1.3567     1.0846     0.9184     0.8384     0.7754     0.7719     0.7577
ESTIMATE  ERROR  AS       112.43      93.82      54.94      31.20      19.77      10.77      10.27       8.24
PERCENTAGE OF ACTUAL
FAILURE RATE

SAMPLE STD DEVIATION      1.2429     1.8888     0.9333     0.6204     0.4628     0.3504     0.3491     0.3192
----------------------------------------------------------------------------------------------------------------

CUMULATIVE TEST TIME       2.166      4.312      6.455      8.609     10.764     12.932     15.076     17.222
----------------------------------------------------------------------------------------------------------------

CUMULATIVE FAILURES       1.3600     2.7800     4.4100     5.8500     7.3500     8.6500    10.1300    11.5600
----------------------------------------------------------------------------------------------------------------


**********************************************************************************************************************


PHASE                          9         10         11         12         13         14         15         16
----------------------------------------------------------------------------------------------------------------

ACTUAL FAILURE RATE       0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME       3.2504     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504
----------------------------------------------------------------------------------------------------------------

MODEL  ESTIMATE           0.1580     0.0929     0.0697     0.0565     0.0499     0.0462     0.0438     0.0419
ESTIMATE  ERROR  AS       216.05      85.82      39.45      12.96       0.25       7.64      12.45      16.29
PERCENTAGE OF ACTUAL
FAILURE RATE

SAMPLE STD DEVIATION      0.0502     0.0320     0.0249     0.0188     0.0152     0.0134     0.0122     0.0114
----------------------------------------------------------------------------------------------------------------

CUMULATIVE TEST TIME      47.306     77.465    107.418    137.666    167.677    197.535    227.437    257.471
----------------------------------------------------------------------------------------------------------------

CUMULATIVE FAILURES      13.0800    14.5500    16.0300    17.2900    18.7300    20.2900    21.6600    23.3800
----------------------------------------------------------------------------------------------------------------
```



```
                                     CASE   5

                                      5 ITEMS

PHASE                           1          2          3          4          5          6          7          8
-------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.7000     0.7000     0.7000     0.7000     0.7000     0.7000     0.7000     0.7000
PLANNED  TEST  TIME        0.2322     0.2322     0.2322     0.2322     0.2322     0.2322     0.2322     0.2322
-------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            7.0034     1.7600     1.1444     1.6976     1.0905     1.0012     0.9440     0.8712
ESTIMATE  ERROR  AS      900.49     151.43      63.49     142.52      55.79      43.03      34.85      24.46
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      27.8616     1.6287     1.0663     5.4117     0.9279     0.7431     0.5924     0.485
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        1.078      2.160      3.261      4.315      5.388      6.463      7.526      8.610
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        0.6000     1.3600     1.9900     2.8400     3.5600     4.3100     5.1700     5.8300
-------------------------------------------------------------------------------------------------------------------

...........................................................................................................................

PHASE                           9         10         11         12         13         14         15         16
-------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME        3.2504     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504     3.2504
-------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            0.1735     0.0938     0.0710     0.0610     0.0526     0.0488     0.0452     0.0437
ESTIMATE  ERROR  AS        247.04      87.68      41.95      22.09       5.11       2.45       9.61      12.62
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.1209     0.0415     0.0288     0.0272     0.0225     0.0211     0.0200     0.0173
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       23.741     38.931     53.903     68.700     83.615     98.725    113.771    128.757
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        6.5300     7.1900     7.9300     8.7100     9.3700    10.1700    10.8200    11.6700
-------------------------------------------------------------------------------------------------------------------
```



NUMBER OF POINTS OUT OF RANGE = 3

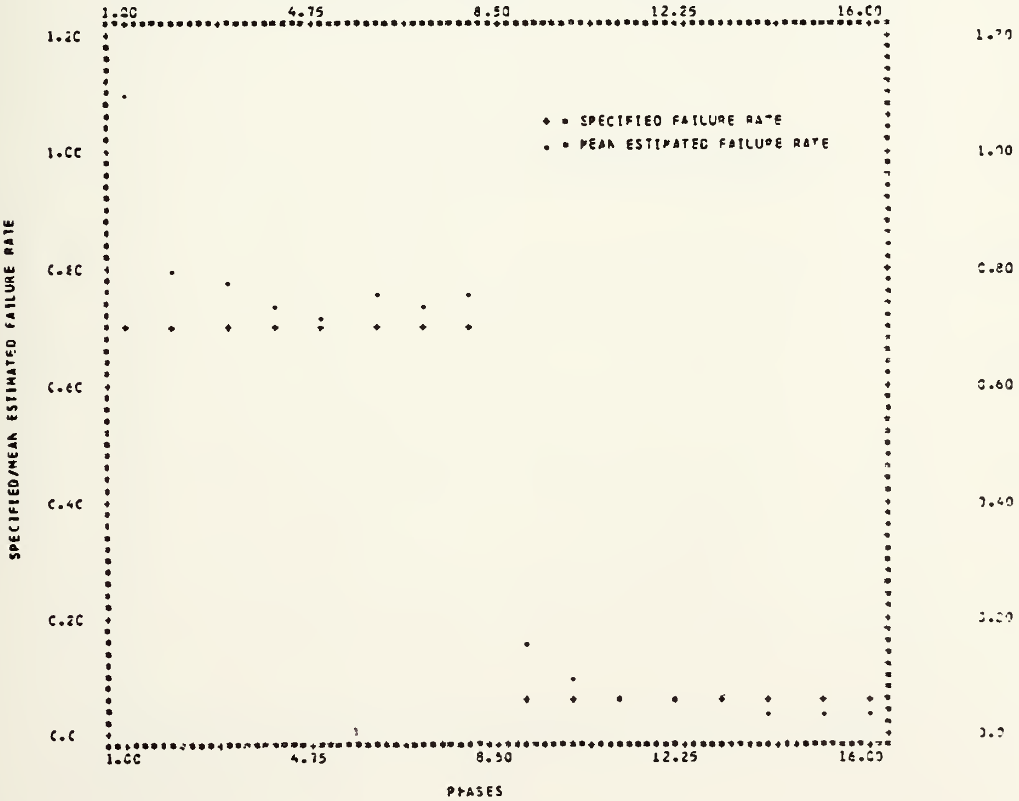
CASE 5

20 ITEMS

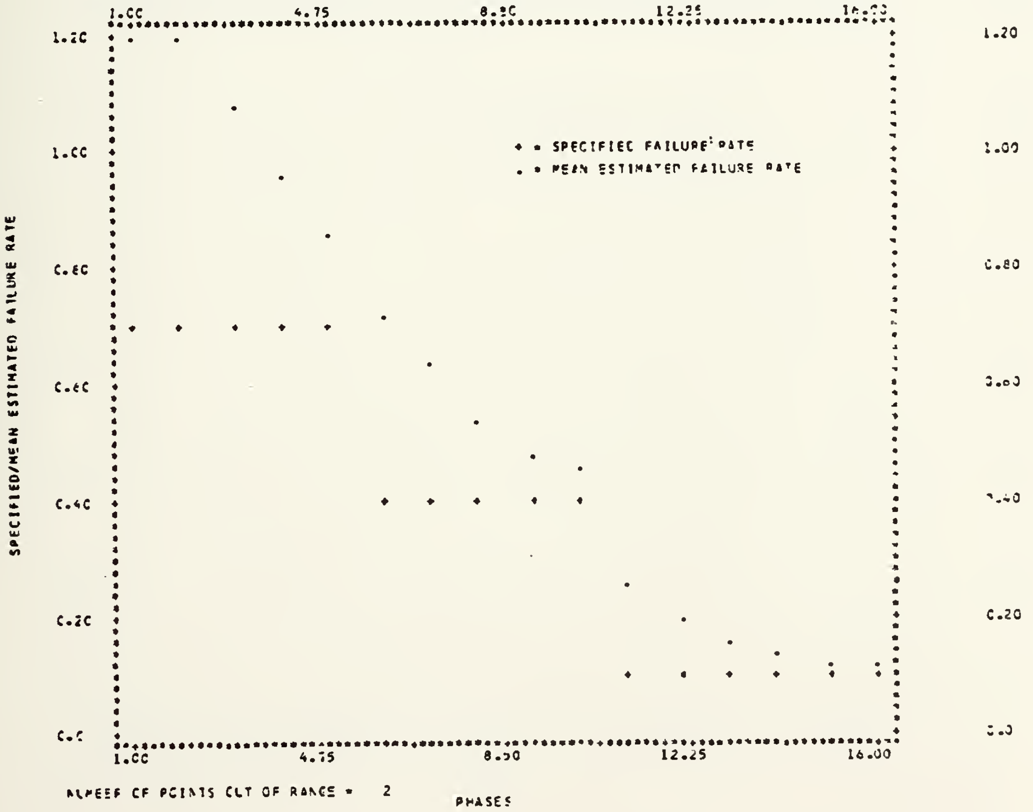
PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.7000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.2322	0.2322	0.2322	0.2322	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	1.0961	0.7966	0.7845	0.7451	0.7287	0.7515	0.7497	0.7551
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	56.58	13.81	12.07	6.45	4.10	7.36	7.11	7.87
SAMPLE STD DEVIATION	0.8540	0.4499	0.3828	0.3081	0.2905	0.2900	0.2909	0.3113
CUMULATIVE TEST TIME	4.288	8.595	12.902	17.214	21.527	25.794	30.060	34.330
CUMULATIVE FAILURES	3.0400	5.8000	8.8200	11.6600	14.5700	17.8400	20.9900	24.2300

* * *

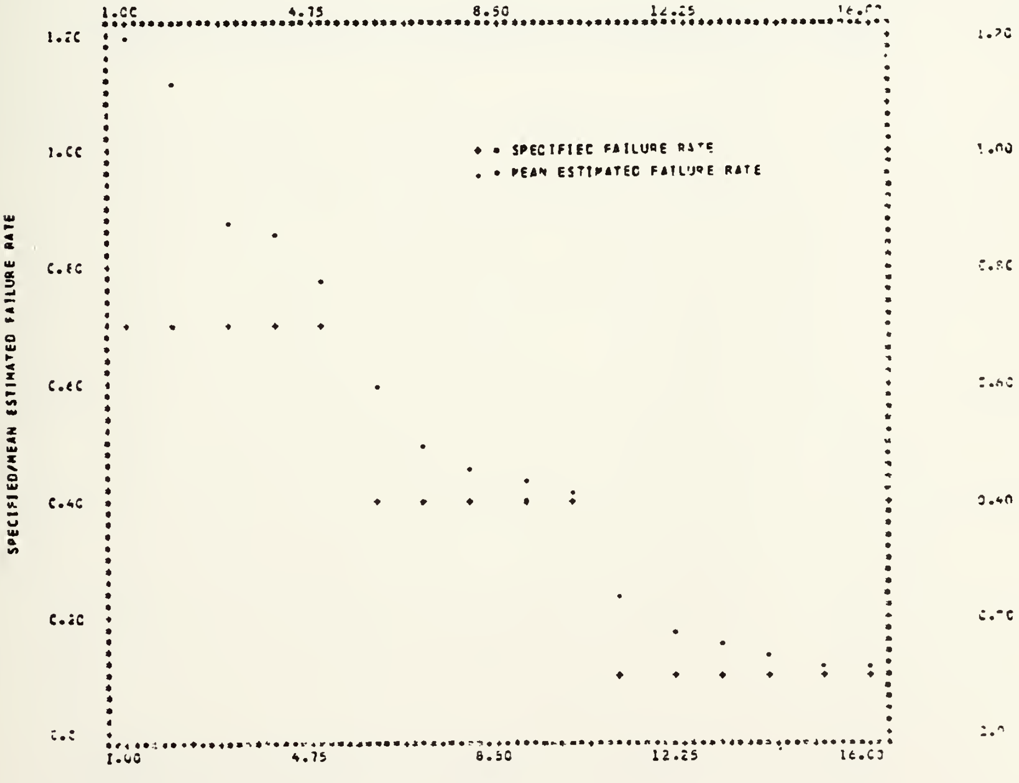
PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.1618	0.0950	0.0699	0.0565	0.0511	0.0472	0.0438	0.0416
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	223.55	90.06	39.80	16.99	2.29	5.70	12.38	16.85
SAMPLE STD DEVIATION	0.0377	0.0208	0.0154	0.0137	0.0120	0.0108	0.0095	0.0089
CUMULATIVE TEST TIME	94.364	154.544	214.944	274.997	335.177	394.997	455.430	515.576
CUMULATIVE FAILURES	27.1800	30.2600	32.9900	36.0100	38.6500	41.9900	44.8700	47.8200



```
                                   CASE   6

                                   5 ITEMS

PHASE                         1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME      0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          8.1372    3.2307    1.0889    0.9594    0.8695    0.7261    0.6357    0.5402
ESTIMATE  ERROR  AS     1062.45    361.53     55.55     37.05     24.22     81.53     59.54     35.05
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    41.6542   12.8530    0.8206    0.8237    0.6671    0.5166    0.4158    0.2582
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      1.061     2.128     3.209     4.305     5.374     7.210     9.075    10.966
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      0.7400    1.4900    2.2200    2.8400    3.5500    4.4600    5.2900    6.0100
------------------------------------------------------------------------------------------------------

**************************************************************************************************************

PHASE                         9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME      0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.4852    0.4598    0.2601    0.1951    0.1608    0.1381    0.1281    0.1155
ESTIMATE  ERROR  AS       21.30     14.95    160.15     95.07     60.80     38.14     28.06     15.51
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.2159    0.2063    0.1126    0.0776    0.0609    0.0529    0.0478    0.0429
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     12.856    14.742    22.241    29.722    37.201    44.676    52.044    59.523
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      6.6800    7.3800    8.0900    8.9000    9.7000   10.4000   11.3000   12.1500
------------------------------------------------------------------------------------------------------
```



```
                                          CASE   6

                                          10 ITEMS

PHASE                         1         2         3         4         5         6         7         8
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2222    0.2222    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.7872    1.1281    0.8811    0.8621    0.7812    0.5977    0.5077    0.4506
ESTIMATE  ERROR  AS       155.31     61.16     25.86     23.16     11.59     49.43     26.92     12.65
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      1.7462    0.9207    0.5958    0.4681    0.3682    0.2647    0.2068    0.1654
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.158     4.277     6.441     8.553    10.729    14.459    18.287    22.093
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.3900    3.0100    4.3300    5.9200    7.2400    8.6600    9.9600   11.2500
---------------------------------------------------------------------------------------------------------

**************************************************************************************************************

PHASE                         9        10        11        12        13        14        15        16
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME       0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.4359    0.4184    0.2492    0.1883    0.1554    0.1366    0.1236    0.1149
ESTIMATE  ERROR  AS         8.99      4.61    149.24     88.29     55.45     36.59     23.61     14.90
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.1644    0.1469    0.0663    0.0576    0.0423    0.0383    0.0295    0.0294
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      25.831    29.565    44.552    59.418    74.439    89.320   104.331   119.306
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      12.7500   14.1900   15.7600   17.4500   19.0200   20.5500   22.1800   23.7400
---------------------------------------------------------------------------------------------------------
```



NUMBER OF POINTS OUT OF RANGE =   1

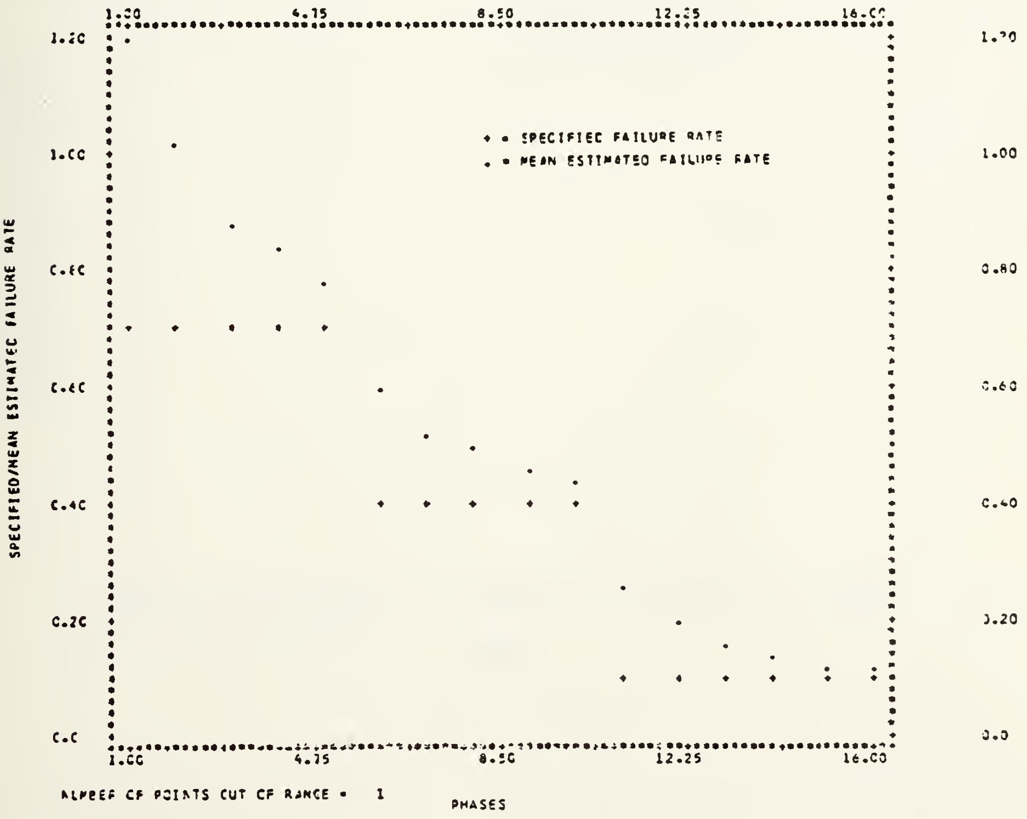
PHASES

CASE 6

20 ITEMS

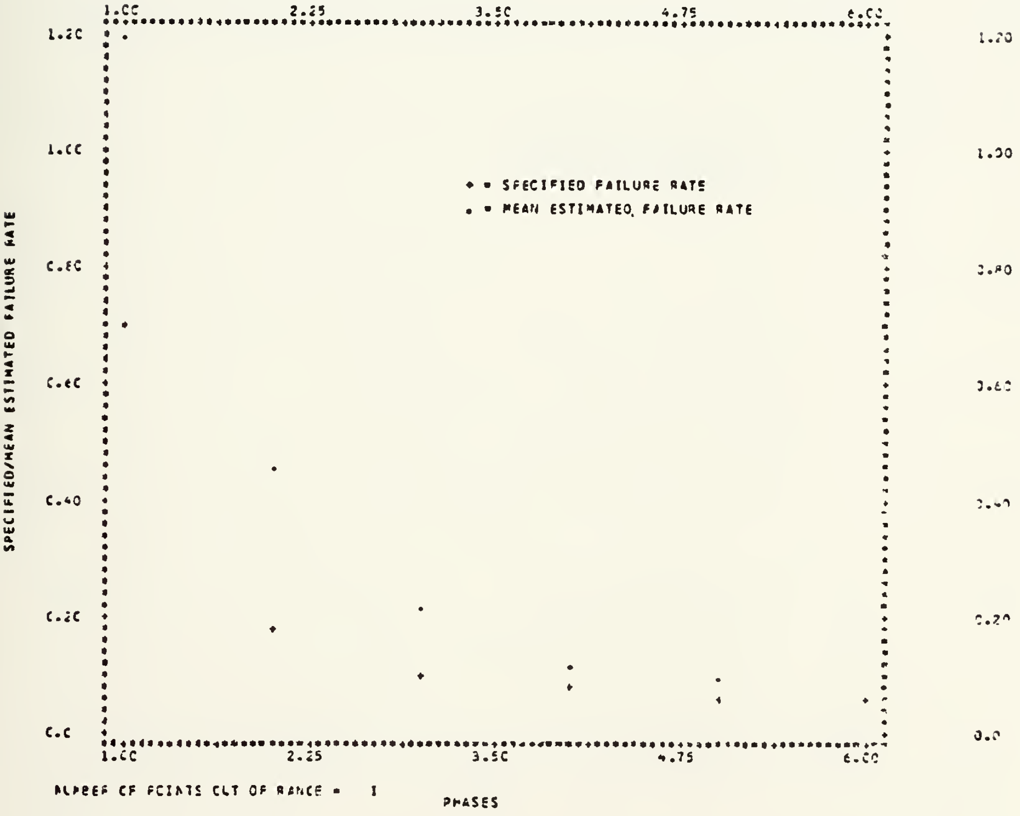
PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.7000	0.7000	0.4000	0.4000	0.4000
PLANNED TEST TIME	0.2322	0.2322	0.2322	0.2322	0.2322	0.4063	0.4063	0.4063
MODEL ESTIMATE	1.2777	1.0114	0.8886	0.8352	0.7894	0.6083	0.5260	0.4959
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	82.53	44.48	26.94	19.32	12.78	52.08	31.49	22.96
SAMPLE STD DEVIATION	1.2163	0.6270	0.4078	0.3046	0.2523	0.1787	0.1497	0.1374
CUMULATIVE TEST TIME	4.294	8.561	12.842	17.130	21.419	28.905	36.410	43.831
CUMULATIVE FAILURES	2.7700	6.0500	9.2000	12.3000	15.2100	18.0700	21.0200	24.3000

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.4063	0.4063	1.6252	1.6252	1.6252	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.4551	0.4389	0.2581	0.1931	0.1571	0.1355	0.1213	0.1116
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	13.76	9.72	158.09	93.06	57.10	35.47	21.31	11.65
SAMPLE STD DEVIATION	0.1217	0.1210	0.0658	0.0431	0.0334	0.0276	0.0241	0.0208
CUMULATIVE TEST TIME	51.373	58.856	88.818	118.437	148.459	178.519	208.549	239.637
CUMULATIVE FAILURES	27.0300	30.0600	33.1700	36.4600	39.4300	42.3500	45.7600	48.2700

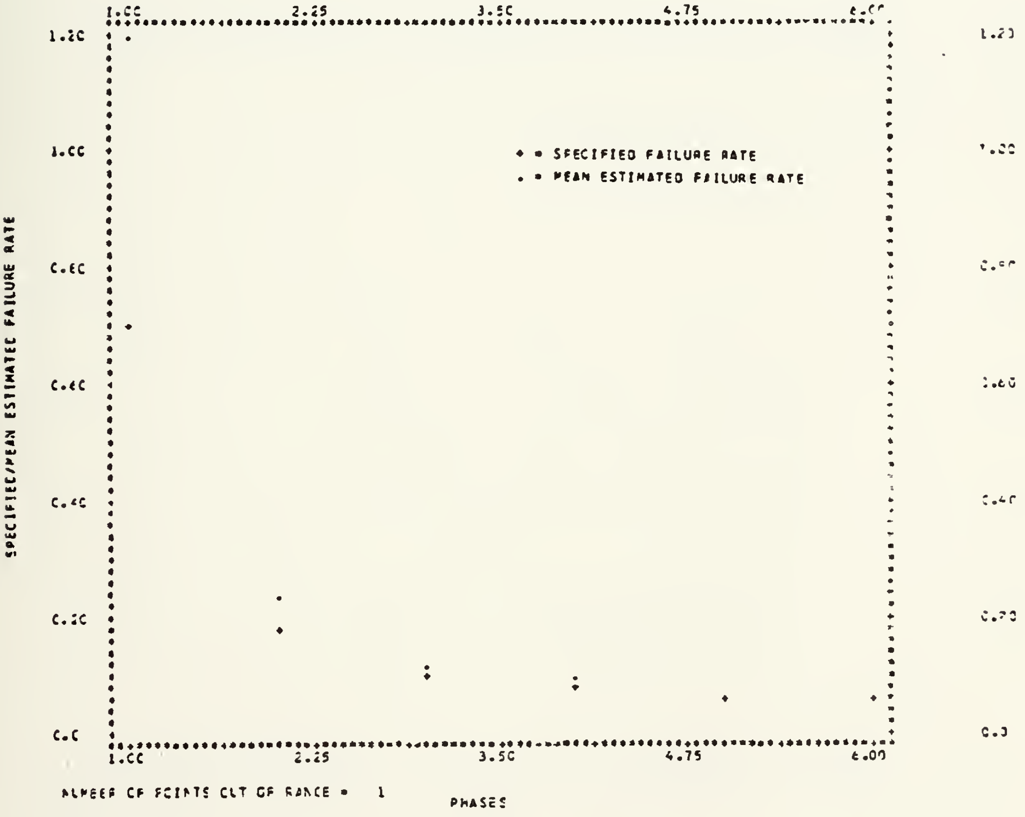


NUMBER OF POINTS OUT OF RANGE = 1

```
                                   CASE  7

                                   5 ITEMS




PHASE                          1          2          3          4          5          6
-----------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000     0.1800     0.1060     0.0760     0.0600     0.0500
PLANNED  TEST  TIME       0.2222     0.9029     1.5332     2.1264     2.7086     3.2904
-----------------------------------------------------------------------------------------
MODEL  ESTIMATE           2.6664     0.4595     0.2102     0.1267     0.0989     0.0648
ESTIMATE  ERROR  AS       280.92     155.26      98.29      66.74      64.89      29.53
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      2.2451     0.3773     0.2323     0.2691     0.1488     0.0529
-----------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.082      5.233     12.335     22.415     34.919     49.990
-----------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.5800     1.4000     2.1100     2.6800     3.4500     4.2000
-----------------------------------------------------------------------------------------
```



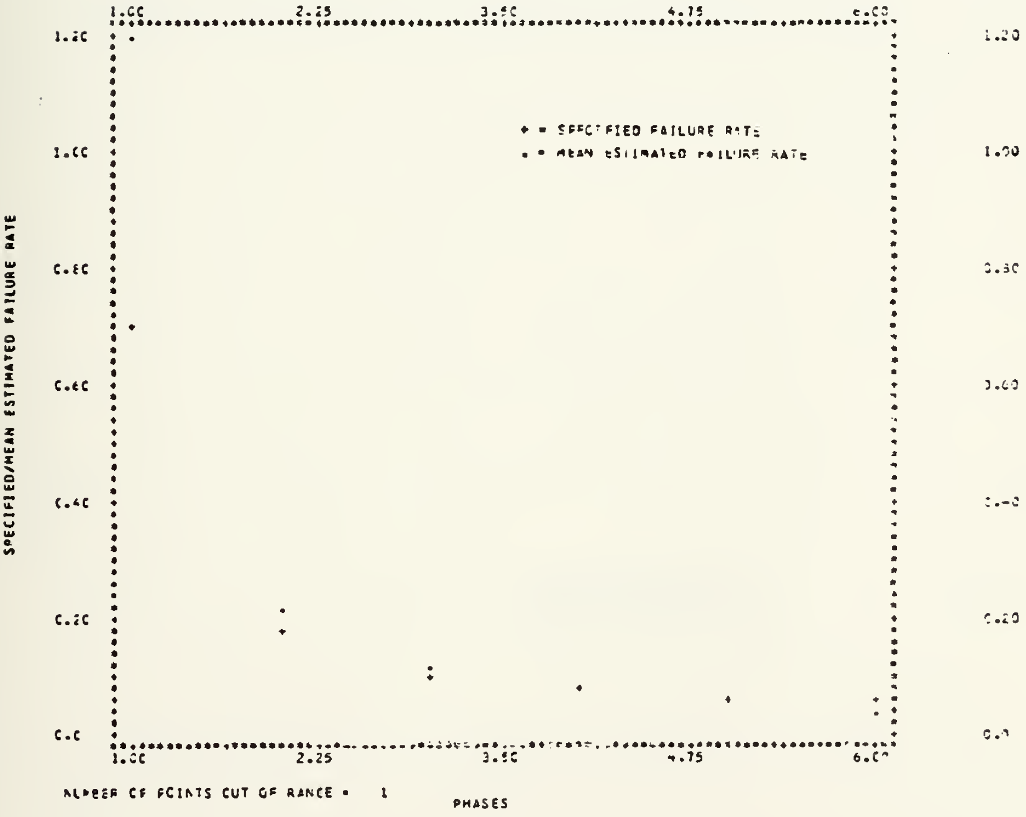
```
                                CASE   7

                                10 ITEMS



PHASE                         1          2          3          4          5          6
-----------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000     0.1800     0.1060     0.0760     0.0600     0.0500
PLANNED  TEST  TIME      0.2322     0.9029     1.5232     2.1384     2.7086     3.2904
-----------------------------------------------------------------------------------------
MODEL  ESTIMATE          1.4664     0.2349     0.1188     0.0935     0.0609     0.0525
ESTIMATE  ERROR  AS      109.49      30.48      12.05      22.99       1.51       4.51
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     1.9720     0.1645     0.0705     0.1298     0.0258     0.0220
-----------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      2.131     10.442     24.658     44.542     65.742     95.645
-----------------------------------------------------------------------------------------
CUMULATIVE FAILURES      1.5200     3.0900     4.5000     5.5700     7.4000     9.0400
-----------------------------------------------------------------------------------------
```



CASE 7

20 ITEMS

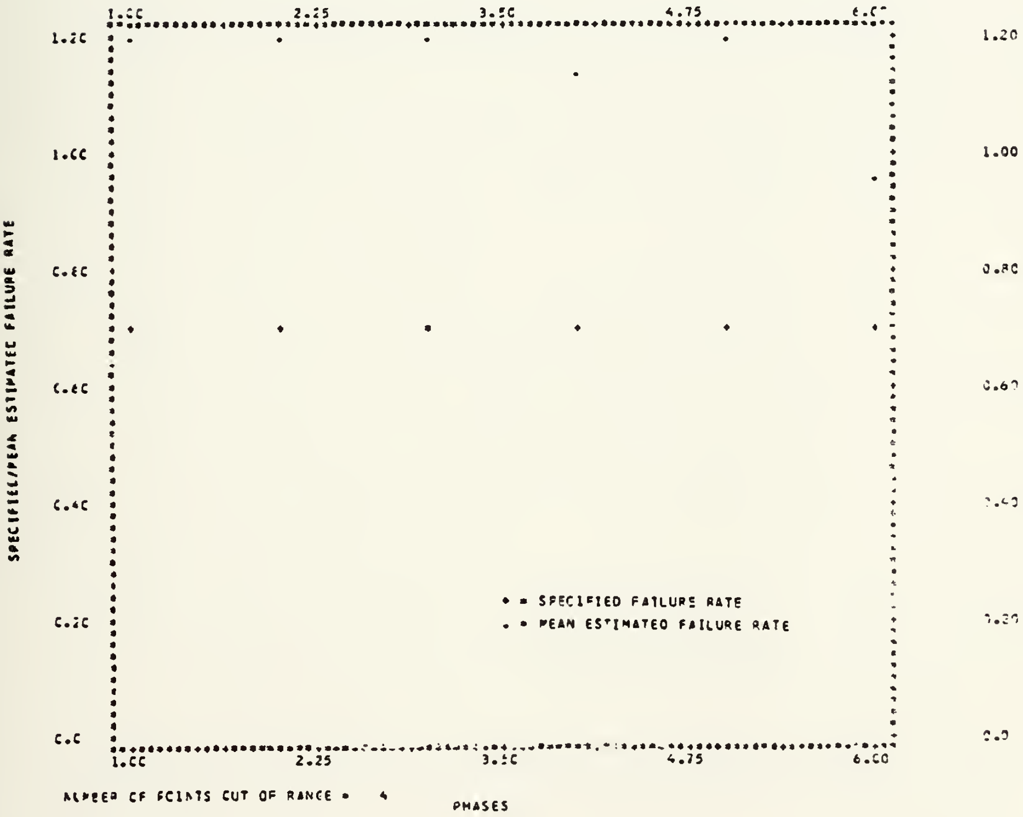
```
PHASE                          1          2          3          4          5          6
------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000     0.1800     0.1060     0.0760     0.0600     0.0500
PLANNED  TEST  TIME       0.2222     0.9029     1.5332     2.1284     2.7086     3.2504
------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.2810     0.2117     0.1117     0.0803     0.0611     0.0496
ESTIMATE  ERROR  AS        83.00      17.60       5.34       5.63       1.77       0.73
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      1.1594     0.1266     0.0577     0.0327     0.0204     0.0159
------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       4.285     21.018     49.447     88.959    135.259    195.321
------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       3.0500     6.0200     8.8200    11.9500    14.5500    17.8000
------------------------------------------------------------------------------------------
```



CASE 8

5 ITEMS

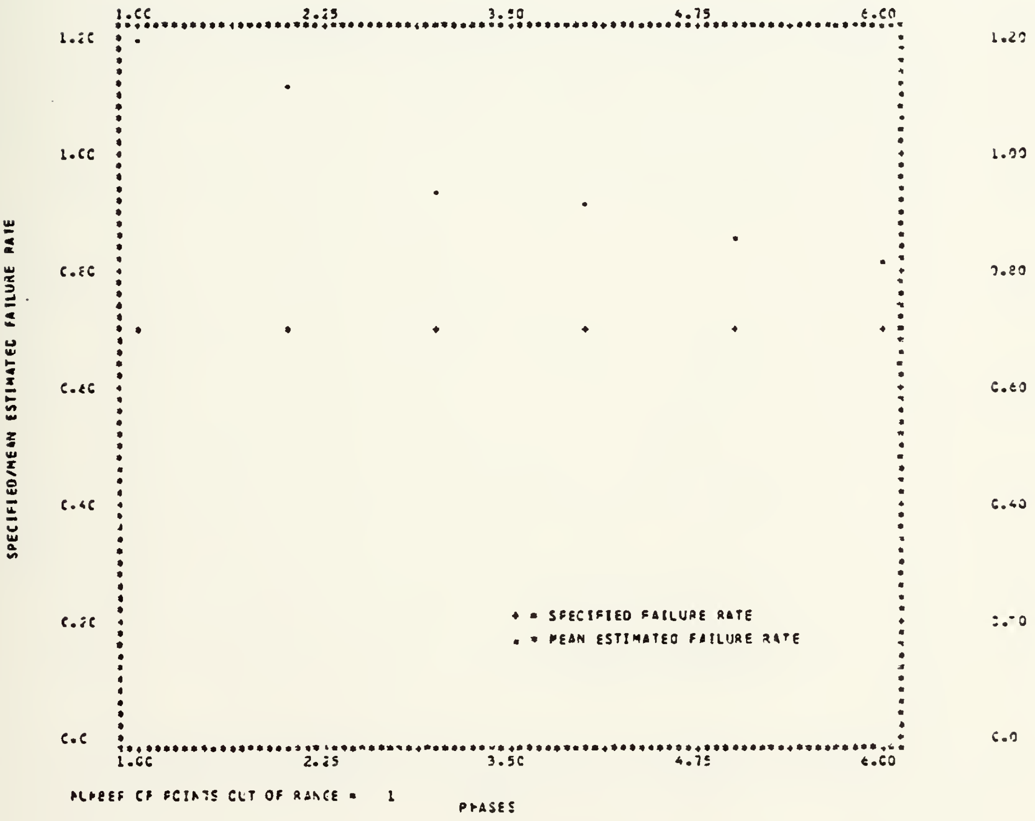
PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.2322	0.2322	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	6.5483	6.2945	1.5116	1.1498	1.7859	0.9689
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	835.47	799.21	115.95	64.26	155.12	38.42
SAMPLE STD DEVIATION	16.5964	36.6878	1.5268	1.0363	7.2352	0.6603
CUMULATIVE TEST TIME	1.075	2.154	3.221	4.309	5.385	6.442
CUMULATIVE FAILURES	0.6000	1.4400	2.1600	2.8500	3.5700	4.4300



CASE 8

10 ITEMS

```
PHASE                          1         2         3         4         5         6
-----------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.7000    0.7000    0.7000    0.7000    0.7000    0.7000
PLANNED  TEST  TIME        0.2322    0.2322    0.2322    0.2322    0.2322    0.2322
-----------------------------------------------------------------------------------
MODEL  ESTIMATE            1.9109    1.1108    0.9497    0.9227    0.8611    0.8247
ESTIMATE  ERROR  AS        172.98     58.69     35.67     31.82     23.01     17.82
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       2.2062    0.9809    0.6116    0.4288    0.4651    0.3530
-----------------------------------------------------------------------------------
CUMULATIVE TEST TIME        2.119     4.262     6.382     8.501    10.645    12.788
-----------------------------------------------------------------------------------
CUMULATIVE FAILURES        1.6200    3.1100    4.7700    6.4300    7.8100    9.3500
-----------------------------------------------------------------------------------
```

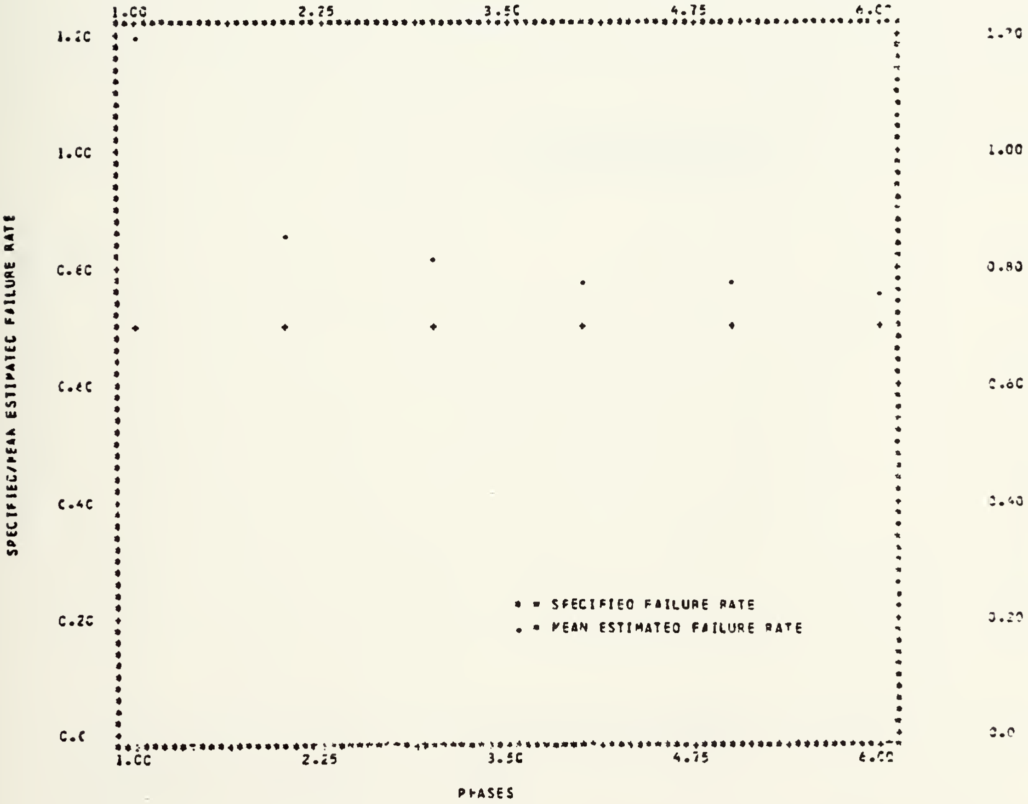


NUMBER OF POINTS OUT OF RANGE = 1

CASE 8

20 ITEMS

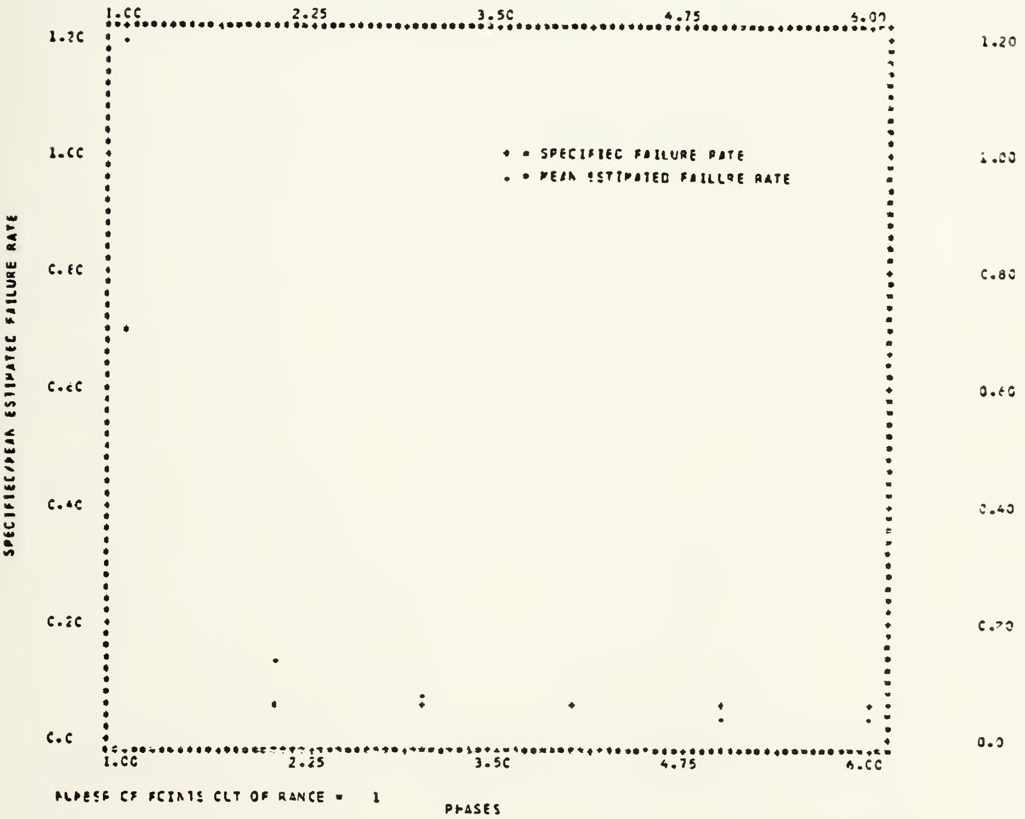
PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.2322	0.2322	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	1.1974	0.8650	0.8298	0.7837	0.7802	0.7658
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	71.06	24.14	18.54	11.95	11.46	9.40
SAMPLE STD DEVIATION	1.0731	0.4682	0.3594	0.2971	0.2620	0.2302
CUMULATIVE TEST TIME	4.301	8.591	12.843	17.144	21.424	25.690
CUMULATIVE FAILURES	2.9200	6.0000	9.2100	12.1900	15.2700	18.3200



CASE 9

5 ITEMS

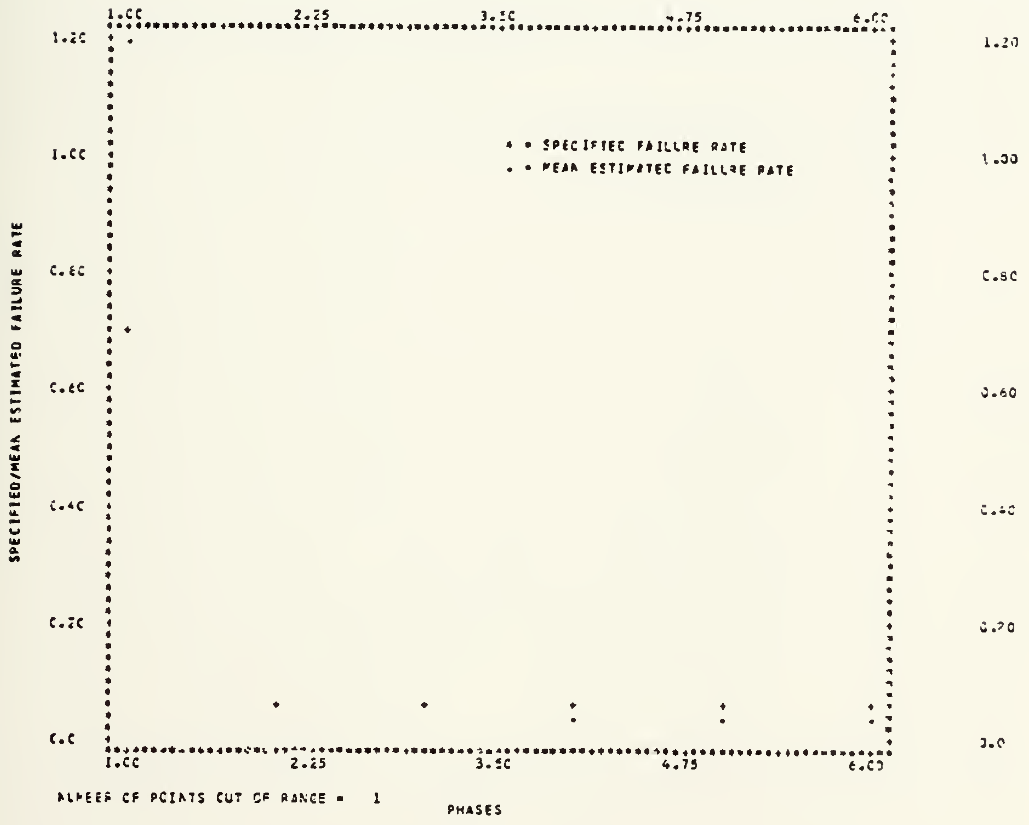
```
PHASE                            1         2         3         4         5         6
-------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000    0.0500    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME         0.2322    3.2504    3.2504    3.2504    3.2504    3.2504
-------------------------------------------------------------------------------------
MODEL  ESTIMATE             3.0001    0.1346    0.0813    0.0568    0.0490    0.0484
ESTIMATE  ERROR  AS         328.59    169.20     62.64     13.65      2.04      3.25
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        3.3772    0.4560    0.0923    0.0539    0.0358    0.0257
-------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         1.066    16.044    30.716    45.800    60.858    75.356
-------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.7100    1.5100    2.4700    3.1300    3.8400    4.6400
-------------------------------------------------------------------------------------
```



CASE 9

10 ITEMS

PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.0500	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2322	3.2504	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	1.2220	0.0512	0.0506	0.0392	0.0418	0.0425
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	74.57	2.43	1.22	21.69	16.43	15.07
SAMPLE STD DEVIATION	1.0980	0.0601	0.1258	0.0227	0.0230	0.0245
CUMULATIVE TEST TIME	2.139	32.360	62.384	92.021	121.829	151.766
CUMULATIVE FAILURES	1.4700	2.8500	4.3600	5.9600	7.6500	9.1500

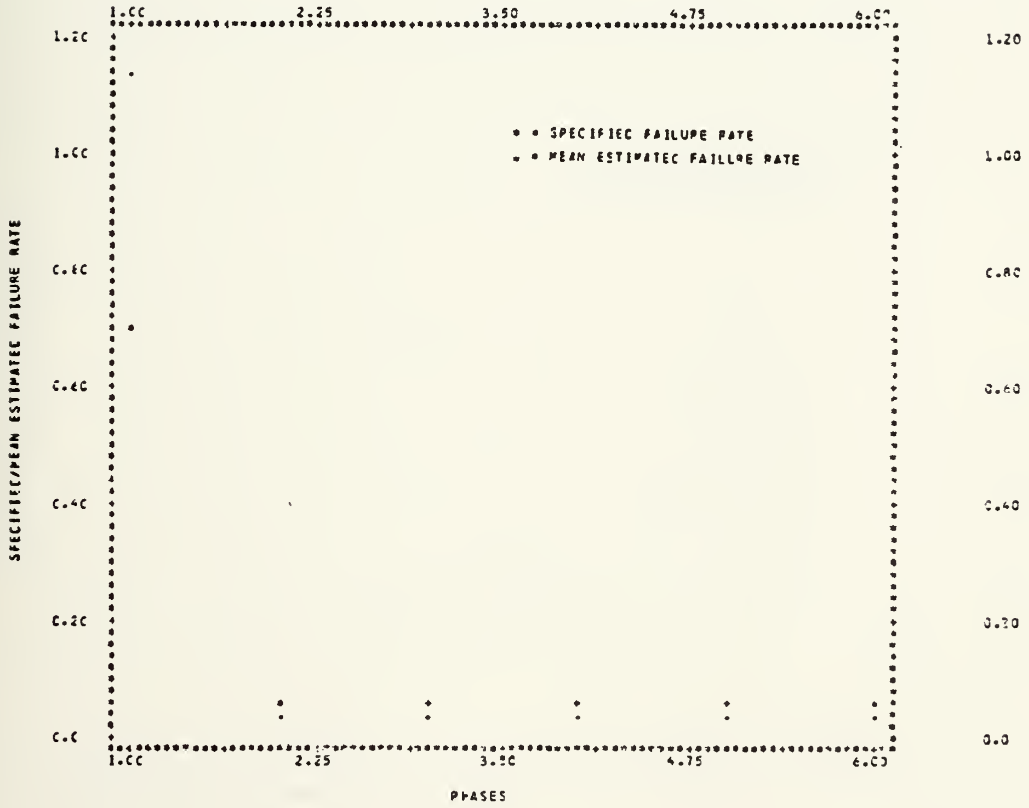


NUMBER OF POINTS OUT OF RANGE = 1

CASE 9

20 ITEMS

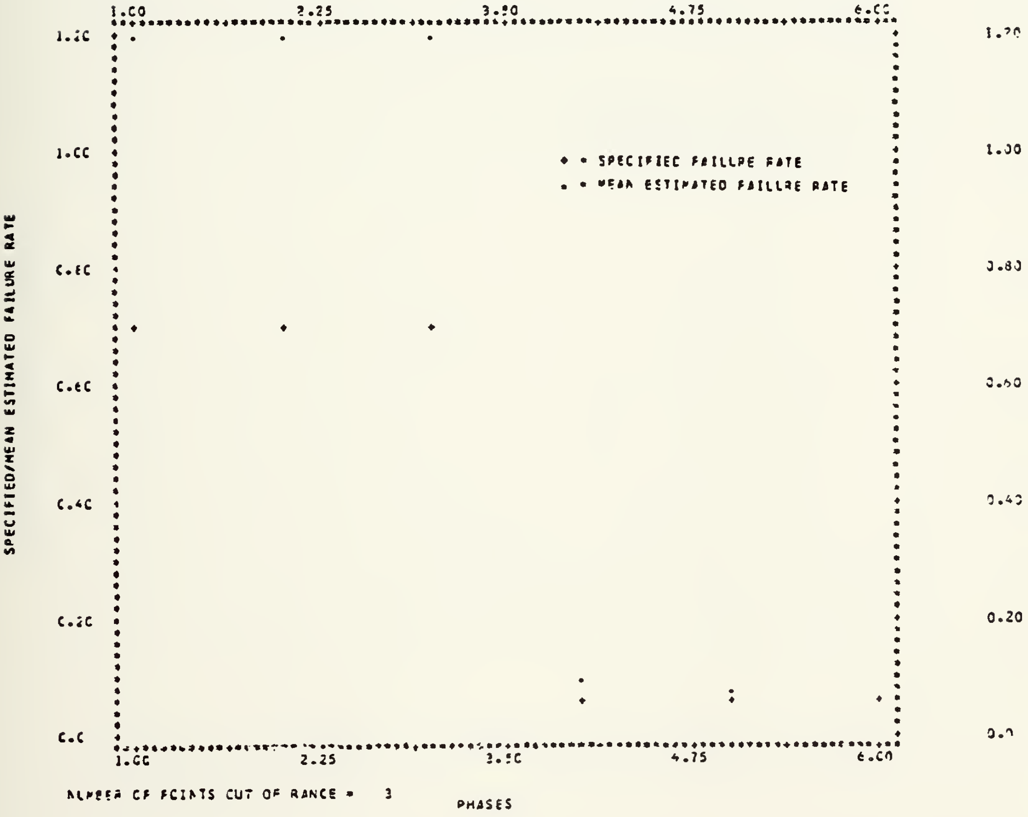
PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.0500	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2322	3.2504	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	1.1359	0.0449	0.0378	0.0392	0.0375	0.0388
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	62.27	10.11	24.46	21.63	24.94	22.44
SAMPLE STD DEVIATION	1.1273	0.0338	0.0163	0.0211	0.0144	0.0132
CUMULATIVE TEST TIME	4.308	64.787	124.266	184.253	244.683	304.580
CUMULATIVE FAILURES	2.8000	5.5400	8.5600	11.6400	14.5200	17.6900



CASE 10

5-ITEMS

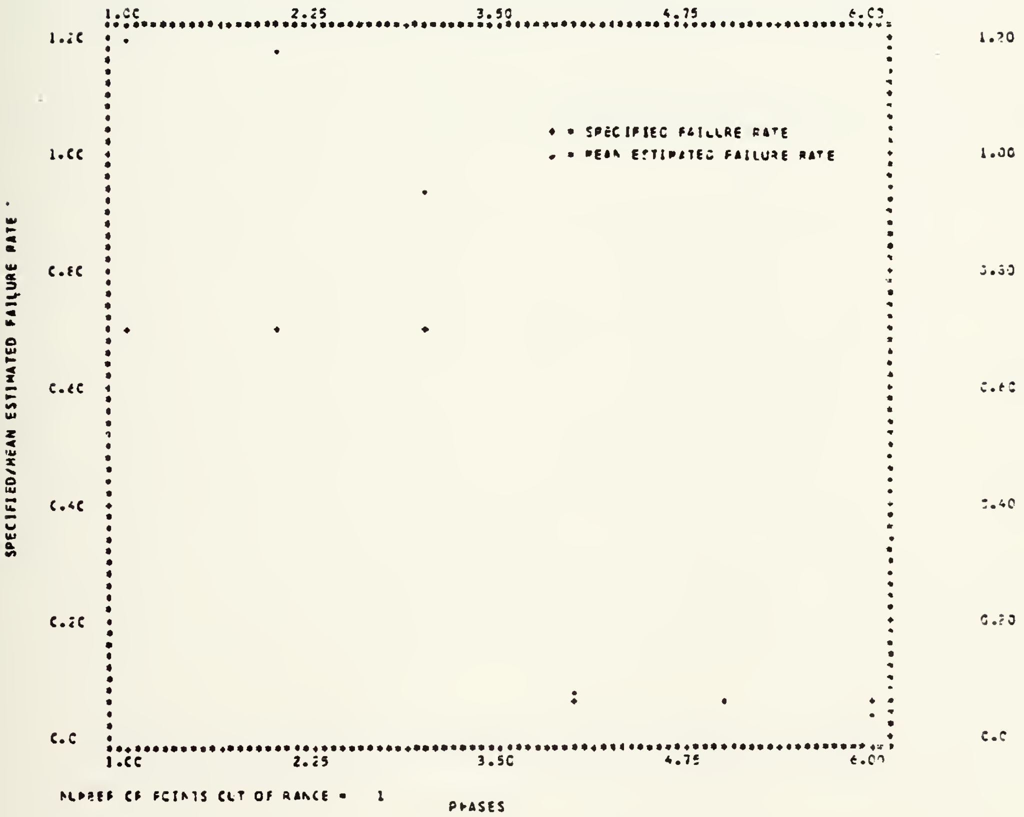
PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2322	0.2222	0.2222	3.2504	3.2504	3.2504
MODEL ESTIMATE	3.1601	1.9107	1.4548	0.1021	0.0805	0.0577
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	351.44	172.96	107.82	104.23	60.92	15.47
SAMPLE STD DEVIATION	4.1693	1.8729	1.6556	0.0706	0.0783	0.0370
CUMULATIVE TEST TIME	1.078	2.144	3.226	18.175	32.837	47.833
CUMULATIVE FAILURES	0.0000	1.4500	2.0800	2.9500	3.8900	4.6400



CASE 10

10 ITEMS

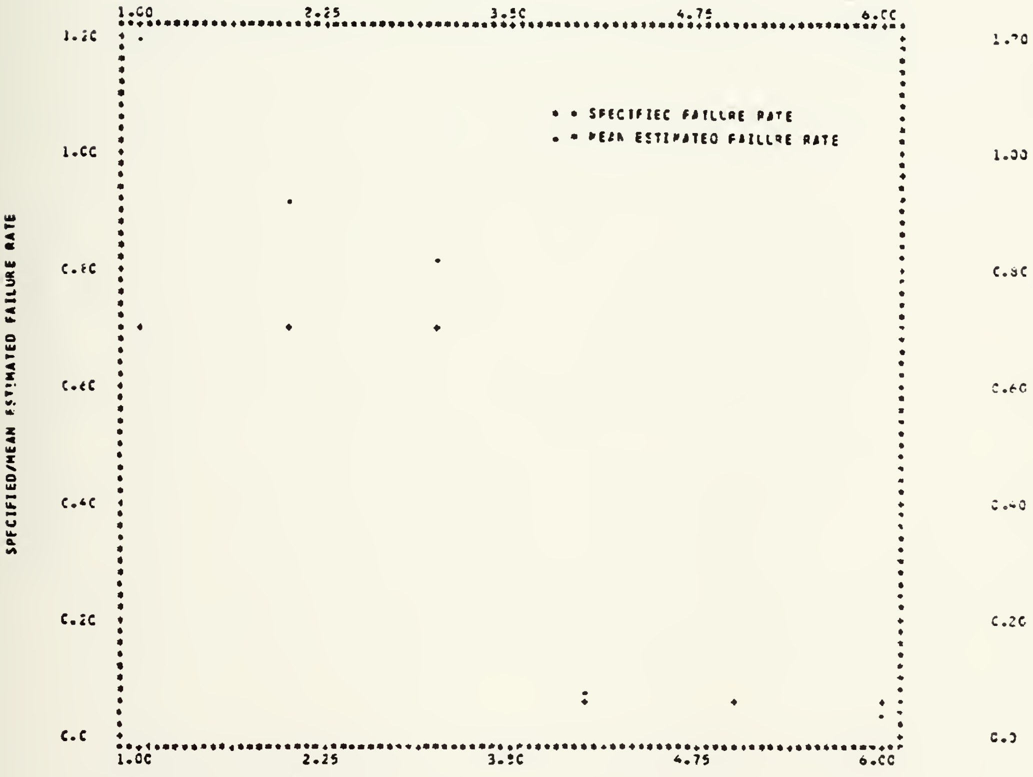
PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2322	0.2322	0.2322	3.2504	3.2504	3.2504
MODEL ESTIMATE	17.6544	1.1887	0.9306	0.0861	0.0537	0.0455
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	2422.05	69.81	32.94	72.14	7.43	8.90
SAMPLE STD DEVIATION	*******	1.0294	0.0296	0.0461	0.0234	0.0186
CUMULATIVE TEST TIME	2.134	4.277	6.418	36.130	66.232	96.210
CUMULATIVE FAILURES	1.5200	3.0200	4.5200	6.1400	7.5800	9.1300



CASE 10

20 ITEMS

PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2322	0.2322	0.2322	3.2504	3.2504	3.2504
MODEL ESTIMATE	1.2568	0.9132	0.8192	0.0769	0.0503	0.0423
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	79.54	30.46	17.03	53.77	0.66	15.47
SAMPLE STD DEVIATION	1.1601	0.5346	0.4100	0.0267	0.0174	0.0129
CUMULATIVE TEST TIME	4.250	8.535	12.825	72.919	133.073	193.287
CUMULATIVE FAILURES	3.1500	6.3100	9.2700	12.0300	15.0500	18.0600



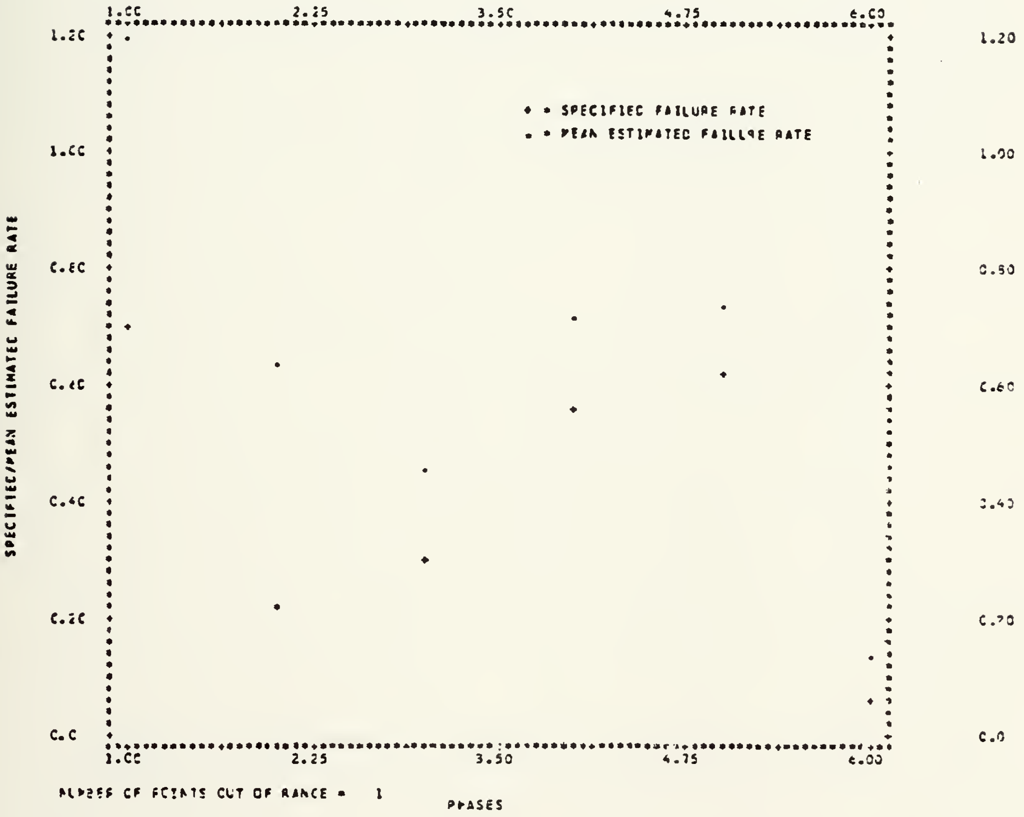
NUMBER OF POINTS OUT OF RANGE = 1

PHASES

CASE 11

5 ITEMS

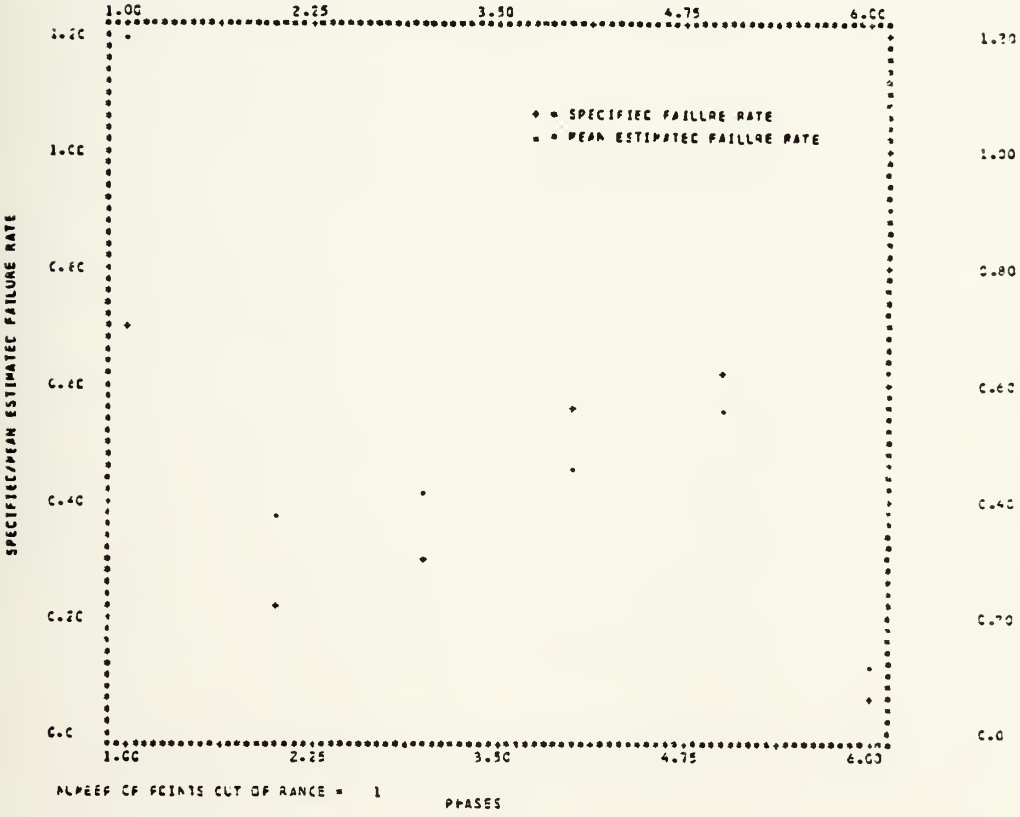
```
PHASE                        1         2         3         4         5         6
--------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.2250    0.3000    0.5500    0.6100    0.0500
PLANNED  TEST  TIME       0.2322    0.7223    0.5417    0.2955    0.2664    3.2504
--------------------------------------------------------------------------------
MODEL  ESTIMATE           2.1895    0.6307    0.4601    0.7153    0.7336    0.1368
ESTIMATE  ERROR  AS       212.79    180.33     53.38     30.06     20.26    173.57
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      2.3593    0.7266    0.3905    0.8522    0.6498    0.0861
--------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.061     4.334     6.850     8.174     9.398    24.311
--------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.6400    1.6000    2.3200    3.2300    4.0400    4.8200
--------------------------------------------------------------------------------
```



CASE 11

10 ITEMS

```
PHASE                          1         2         3         4         5         6
------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.2250    0.3000    0.5500    0.6100    0.0500
PLANNED  TEST  TIME       0.2322    0.7223    0.5417    0.2955    0.2664    3.2504
------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.5355    0.3774    0.4103    0.4614    0.5680    0.1256
ESTIMATE  ERROR  AS       119.36     67.73     36.78     16.11      6.88    151.23
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      1.8078    0.3559    0.5967    0.3514    0.3702    0.0536
------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.152     8.799    13.780    16.489    18.896    48.642
------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.3800    2.9400    4.5200    6.1000    7.9500    9.4900
------------------------------------------------------------------------------------
```

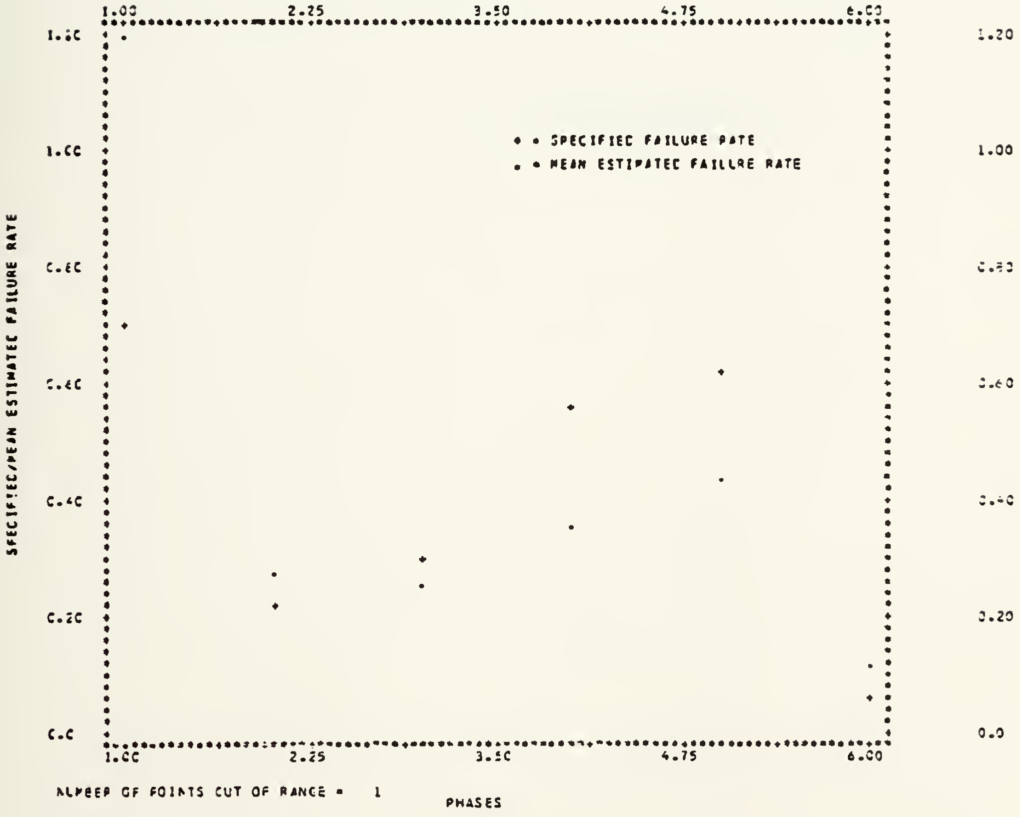


NUMBER OF POINTS OUT OF RANGE = 1

CASE 11

20 ITEMS

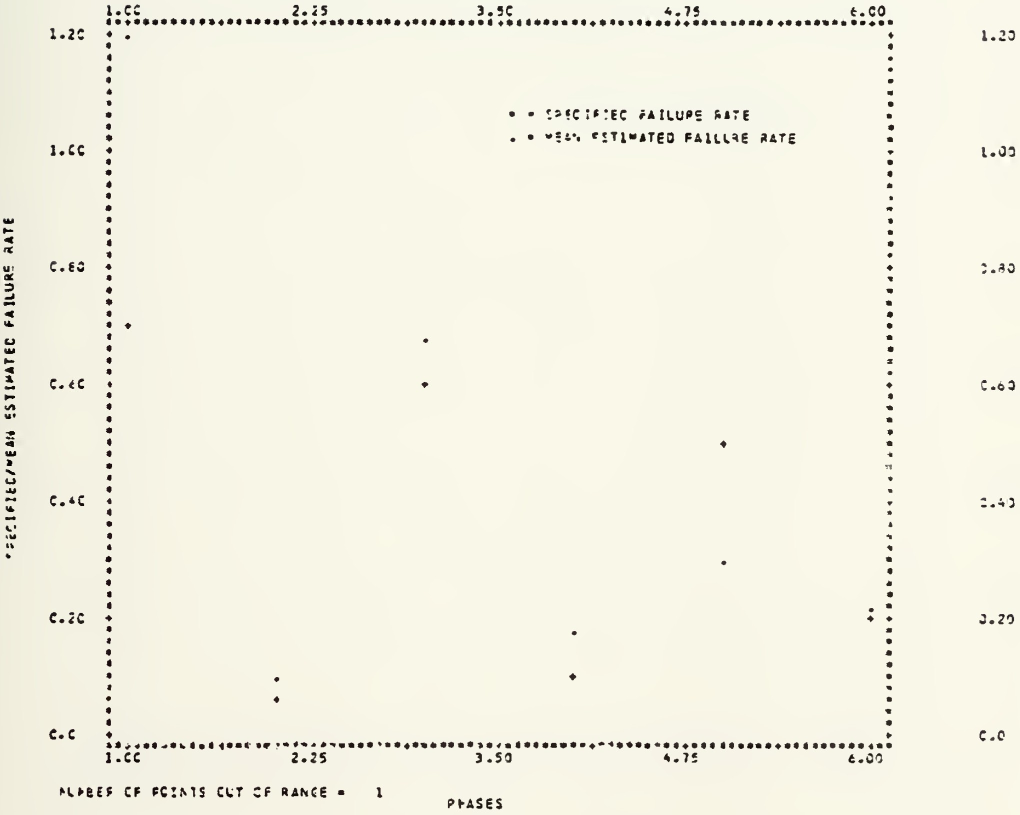
```
PHASE                          1         2         3         4         5         6
------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.2250    0.3000    0.5500    0.6100    0.0500
PLANNED  TEST  TIME       0.2322    0.7223    0.5417    0.2955    0.2664    3.2504
------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.2623    0.2759    0.2641    0.3507    0.4363    0.1140
ESTIMATE  ERROR  AS        80.33     22.61     11.96     36.24     28.47    127.98
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      1.1929    0.1555    0.1286    0.1534    0.1742    0.0371
------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       4.305    17.622    27.723    33.145    38.013    97.892
------------------------------------------------------------------------------------
CUMULATIVE FAILURES       2.9900    5.9900    8.8200   11.9700   15.3400   18.3400
------------------------------------------------------------------------------------
```



CASE 12

5 ITEMS

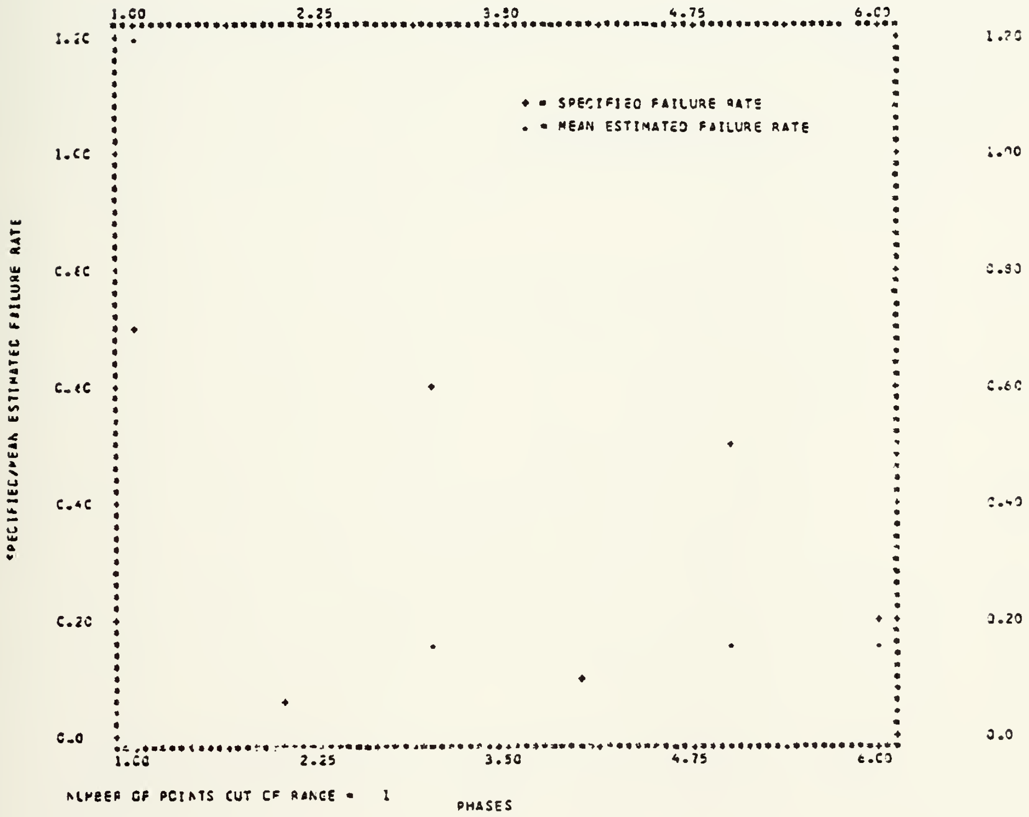
```
PHASE                         1         2         3         4         5         6
-----------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000    0.0500    0.6000    0.1000    0.5000    0.2000
PLANNED  TEST  TIME      0.2322    3.2804    0.2709    1.6252    0.3250    0.8126
-----------------------------------------------------------------------------------
MODEL  ESTIMATE          2.6735    0.1042    0.6812    0.1809    0.3008    0.2121
ESTIMATE  ERROR  AS      281.93    108.45     13.54     80.87     39.85      6.04
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     4.1245    0.1813    1.5503    0.1921    0.5044    0.1926
-----------------------------------------------------------------------------------
CUMULATIVE TEST TIME      1.071    15.554    17.191    24.740    26.225    30.031
-----------------------------------------------------------------------------------
CUMULATIVE FAILURES      0.6300    1.4600    2.3600    3.1000    3.8700    4.4700
-----------------------------------------------------------------------------------
```



CASE 12

10 ITEMS

```
PHASE                            1          2          3          4          5          6
-------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000     0.0500     0.6000     0.1000     0.5000     0.2000
PLANNED  TEST  TIME         0.2322     3.2504     0.2709     1.6252     0.3250     0.8126
-------------------------------------------------------------------------------------------
MODEL  ESTIMATE             4.7415     0.0632     0.1653     0.1080     0.1536     0.1602
ESTIMATE  ERROR  AS         577.36      26.50      72.46       8.01      69.28      19.92
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       24.3199     0.0610     0.2669     0.0750     0.1179     0.1070
-------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         2.130     32.160     34.663     49.818     52.822     60.420
-------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         1.4300     2.9300     4.4600     5.8600     7.3600     8.7000
-------------------------------------------------------------------------------------------
```

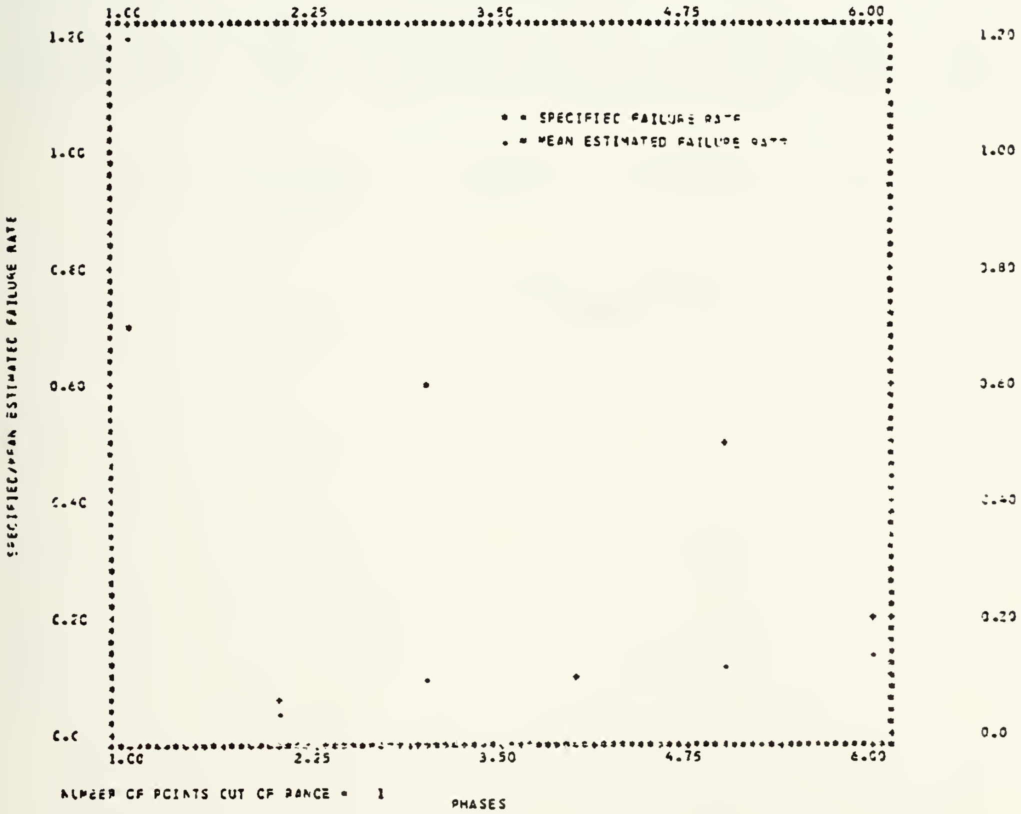


NUMBER OF POINTS OUT OF RANGE = 1

CASE 12

20 ITEMS

PHASE	1	2	3	4	5	6
ACTUAL FAILURE RATE	0.7000	0.0500	0.6000	0.1000	0.5000	0.2000
PLANNED TEST TIME	0.2322	3.2504	0.2709	1.6252	0.3250	0.8126
MODEL ESTIMATE	1.3544	0.0467	0.0941	0.0913	0.1258	0.1415
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	93.49	6.63	84.31	8.74	74.83	29.03
SAMPLE STD DEVIATION	1.5688	0.0296	0.0513	0.0426	0.0535	0.0610
CUMULATIVE TEST TIME	4.248	64.625	69.629	99.672	105.672	120.636
CUMULATIVE FAILURES	3.2700	6.1100	9.0400	12.1300	15.0400	18.0700



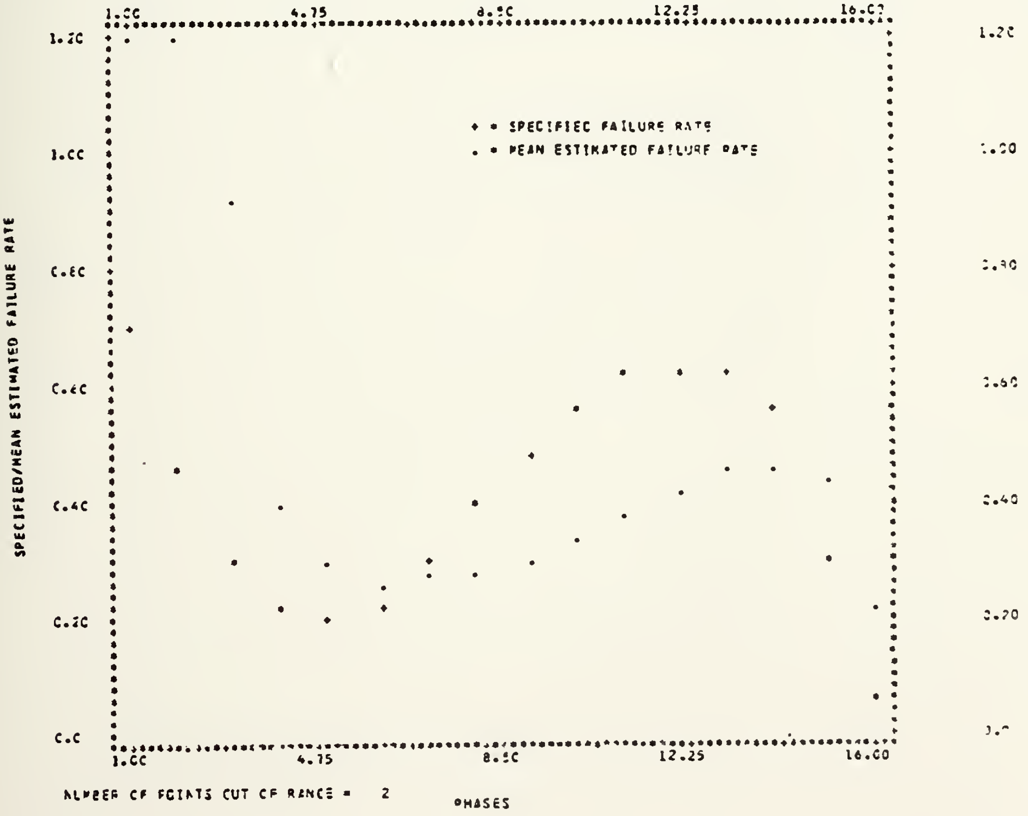
NUMBER OF POINTS OUT OF RANGE = 1

CASE 13

5 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.4500	0.3000	0.2250	0.2000	0.2250	0.3000	0.4000
PLANNED TEST TIME	0.2322	0.3612	0.5417	0.7223	0.8126	0.7223	0.5417	0.4063
MODEL ESTIMATE	2.1655	1.2919	0.9266	0.4025	0.3071	0.2629	0.2761	0.2789
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	209.36	187.10	208.88	78.89	53.55	16.83	7.98	30.28
SAMPLE STD DEVIATION	1.7129	1.2175	2.3761	0.3381	0.2777	0.1625	0.1523	0.1685
CUMULATIVE TEST TIME	1.084	2.741	5.213	8.521	12.284	15.637	18.138	20.056
CUMULATIVE FAILURES	0.5900	1.4300	2.2100	3.0500	3.7900	4.5000	5.2600	5.8700

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4750	0.5500	0.6100	0.6250	0.6100	0.5500	0.3000	0.0500
PLANNED TEST TIME	0.3421	0.2955	0.2664	0.2600	0.2664	0.2955	0.5417	3.7334
MODEL ESTIMATE	0.2963	0.3387	0.3831	0.4242	0.4584	0.4689	0.4367	0.2226
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	37.62	38.42	37.20	32.12	24.85	14.75	45.57	345.21
SAMPLE STD DEVIATION	0.1803	0.2024	0.2230	0.2458	0.3160	0.2342	0.2118	0.0939
CUMULATIVE TEST TIME	21.655	23.016	24.225	25.423	26.636	27.996	30.517	49.529
CUMULATIVE FAILURES	6.4700	7.3000	8.1400	8.9600	9.7600	10.6100	11.3100	12.1000



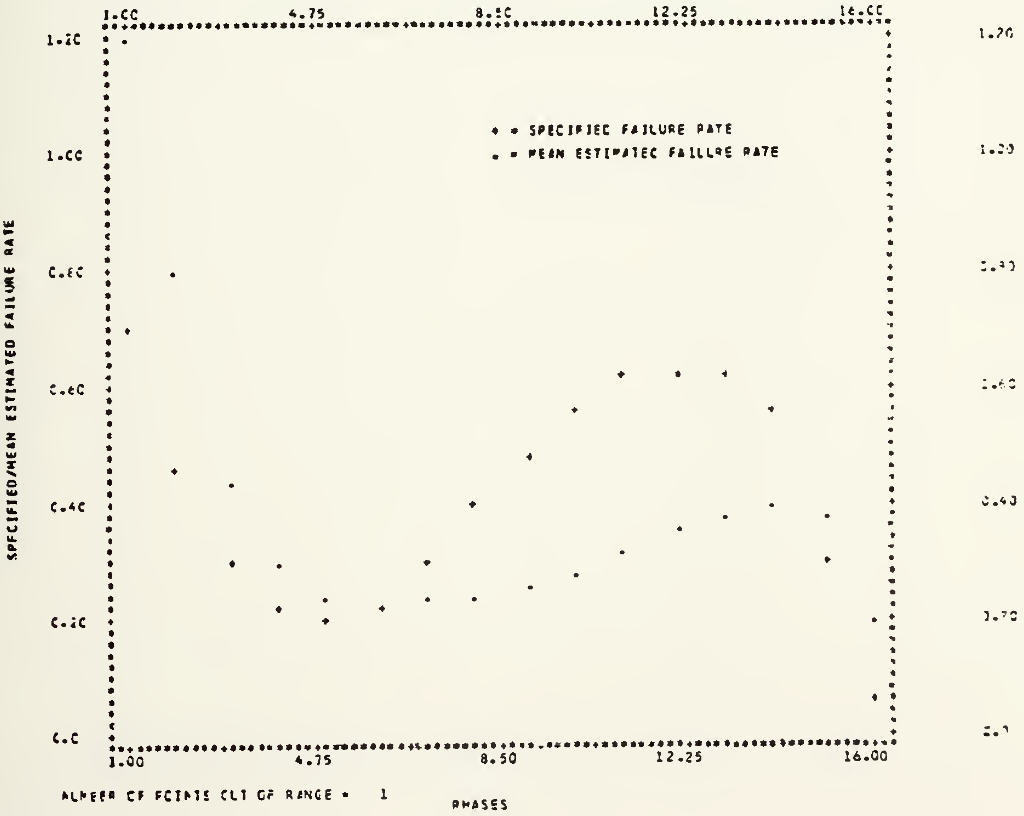
NUMBER OF POINTS OUT OF RANGE = 2

CASE 13

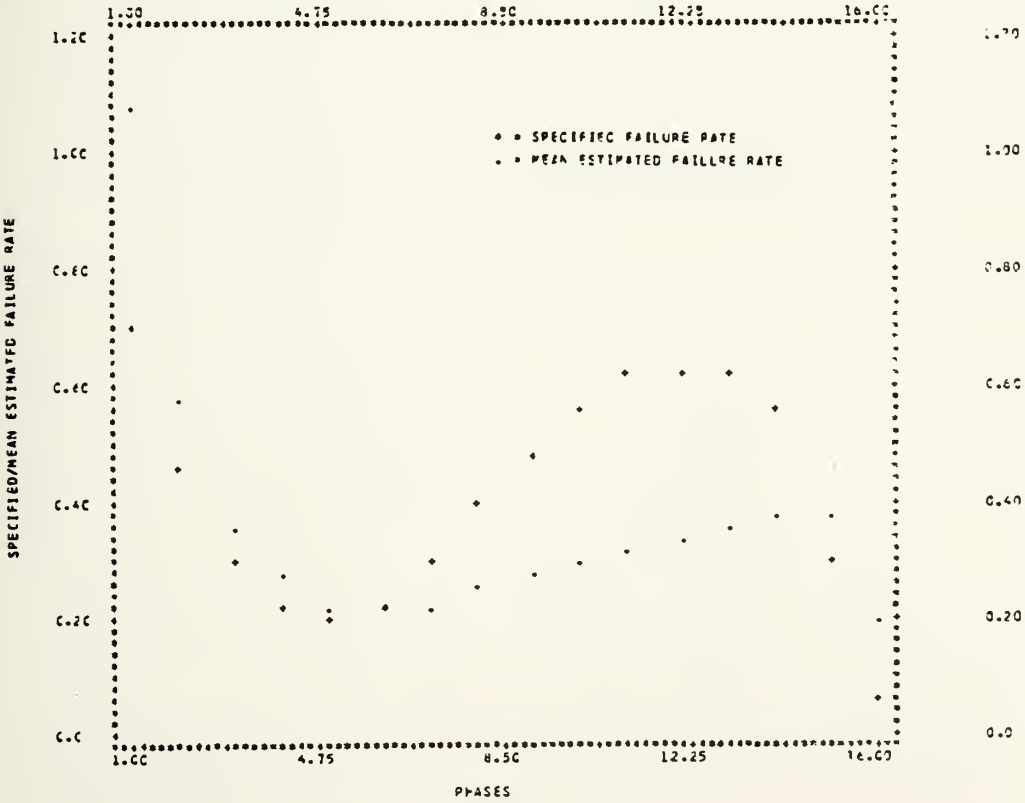
10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.4500	0.3000	0.2250	0.2000	0.2250	0.3000	0.4000
PLANNED TEST TIME	0.2322	0.3612	0.5417	0.7223	0.8126	0.7223	0.5417	0.4063
MODEL ESTIMATE	2.0712	0.8055	0.4461	0.3011	0.2488	0.2260	0.2335	0.2442
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	195.89	79.00	48.71	33.84	24.39	0.45	22.15	38.95
SAMPLE STD DEVIATION	2.4201	0.9641	0.3452	0.1538	0.1085	0.0966	0.1015	0.0943
CUMULATIVE TEST TIME	2.114	5.466	10.457	17.116	24.621	31.344	36.371	40.172
CUMULATIVE FAILURES	1.5600	3.2400	4.6000	6.1800	7.7500	9.1100	10.4900	11.7900

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4750	0.5500	0.6100	0.6250	0.6100	0.5500	0.3000	0.0500
PLANNED TEST TIME	0.3421	0.2555	0.2664	0.2600	0.2664	0.2555	0.5417	3.7504
MODEL ESTIMATE	0.2631	0.2833	0.3187	0.3502	0.3770	0.3985	0.3886	0.1993
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	44.61	48.49	47.75	43.97	38.20	27.55	29.52	298.61
SAMPLE STD DEVIATION	0.1144	0.1052	0.1199	0.1297	0.1384	0.1498	0.1446	0.0588
CUMULATIVE TEST TIME	43.361	46.123	48.581	50.967	53.426	56.146	61.066	91.349
CUMULATIVE FAILURES	13.0500	14.3800	16.0100	17.6000	19.1400	20.6300	22.2300	23.5800



```
                                    CASE  13

                                    20 ITEMS

PHASE                          1         2         3         4         5         6         7         8
-----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.4500    0.3000    0.2250    0.2000    0.2250    0.3000    0.4000
PLANNED  TEST  TIME       0.2322    0.3612    0.5417    0.7223    0.8126    0.7223    0.5417    0.4063
-----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.0814    0.5749    0.3574    0.2743    0.2243    0.2144    0.2286    0.2505
ESTIMATE  ERROR  AS        54.48     27.75     19.15     21.93     12.13      4.70     23.79     37.26
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.3251    0.3507    0.1542    0.1061    0.0731    0.0767    0.0803    0.0810
-----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       4.285    10.955    21.010    34.271    49.286    62.670    72.571    80.027
-----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       3.0100    5.5500    8.8700   12.0200   15.0100   18.0000   21.1700   24.2300
-----------------------------------------------------------------------------------------------------

**************************************************************************************************************

PHASE                          9        10        11        12        13        14        15        16
-----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4750    0.5500    0.6100    0.6250    0.6100    0.5500    0.3000    0.0500
PLANNED  TEST  TIME       0.3421    0.2955    0.2664    0.2600    0.2664    0.2955    0.5417    3.2504
-----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.2736    0.2985    0.3251    0.3494    0.3697    0.3893    0.3794    0.2014
ESTIMATE  ERROR  AS        42.41     45.72     46.71     44.10     39.39     29.23     26.48    302.73
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.0907    0.0855    0.0877    0.0921    0.0906    0.0874    0.0813    0.0387
-----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      86.320    91.794    96.751   101.574   106.504   111.997   121.855   182.120
-----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      27.1300   30.0800   33.0600   35.9700   38.8100   41.9000   45.1200   47.5500
-----------------------------------------------------------------------------------------------------
```



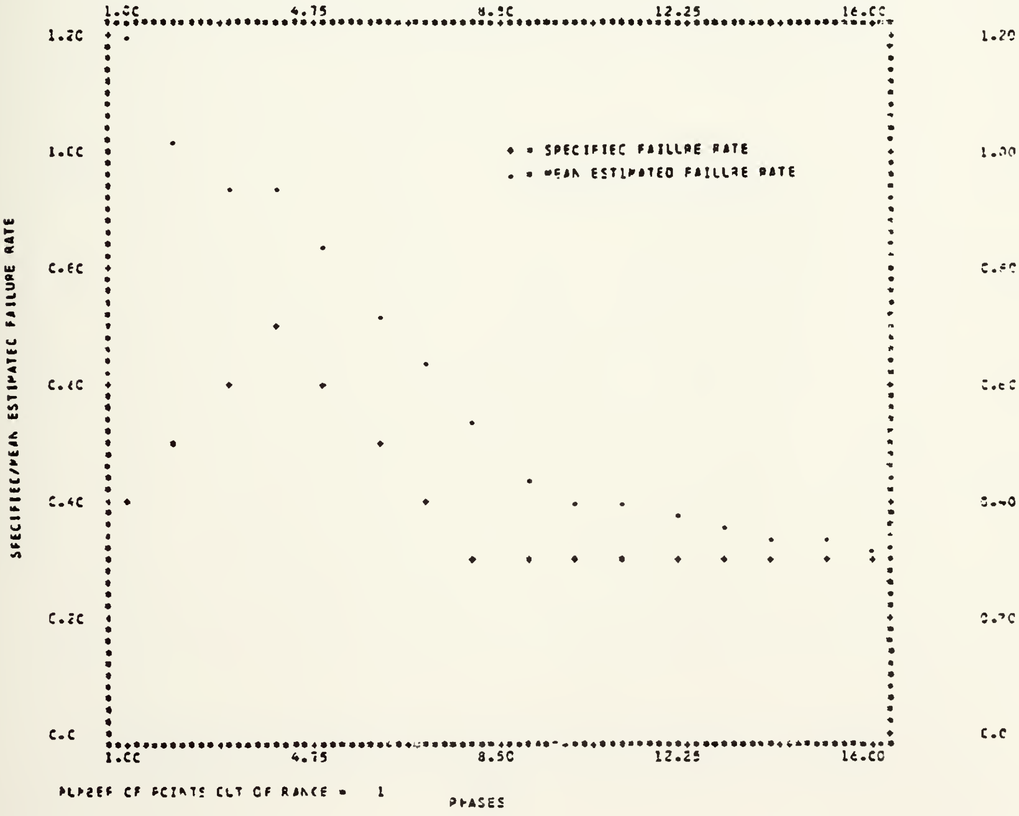
CASE 14

5 ITEMS

```
PHASE                           1         2         3         4         5         6         7         8
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.4000    0.5000    0.6000    0.7000    0.6000    0.5000    0.4000    0.3000
PLANNED  TEST  TIME        0.4063    0.3250    0.2709    0.2322    0.2709    0.3250    0.4063    0.5417
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            1.2017    1.0294    0.9462    0.9438    0.8370    0.7277    0.6429    0.5372
ESTIMATE  ERROR  AS        200.44    105.88     57.71     34.83     39.50     45.54     60.72     79.05
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.8653    1.0244    0.9428    0.8915    0.6107    0.4519    0.3990    0.3277
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        1.901     3.419     4.675     5.754     7.016     8.922    10.392    12.875
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        0.6300    1.3000    2.0700    2.8100    3.5400    4.3100    5.0100    5.8000
---------------------------------------------------------------------------------------------------------
```

****

```
PHASE                           9        10        11        12        13        14        15        16
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.3000    0.3000    0.3000    0.3000    0.3000    0.3000    0.3000    0.3000
PLANNED  TEST  TIME        0.5417    0.5417    0.5417    0.5417    0.5417    0.5417    0.5417    0.5417
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            0.4457    0.4034    0.3946    0.3751    0.3512    0.3369    0.3312    0.3197
ESTIMATE  ERROR  AS         48.56     34.47     31.52     25.03     17.06     12.30     10.40      6.57
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.2358    0.2051    0.1958    0.1731    0.1414    0.1304    0.1289    0.1188
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       15.418    17.919    20.376    22.857    25.381    27.885    30.394    32.911
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        6.4400    7.1700    8.0500    8.8100    9.4600   10.1400   10.9100   11.5700
---------------------------------------------------------------------------------------------------------
```

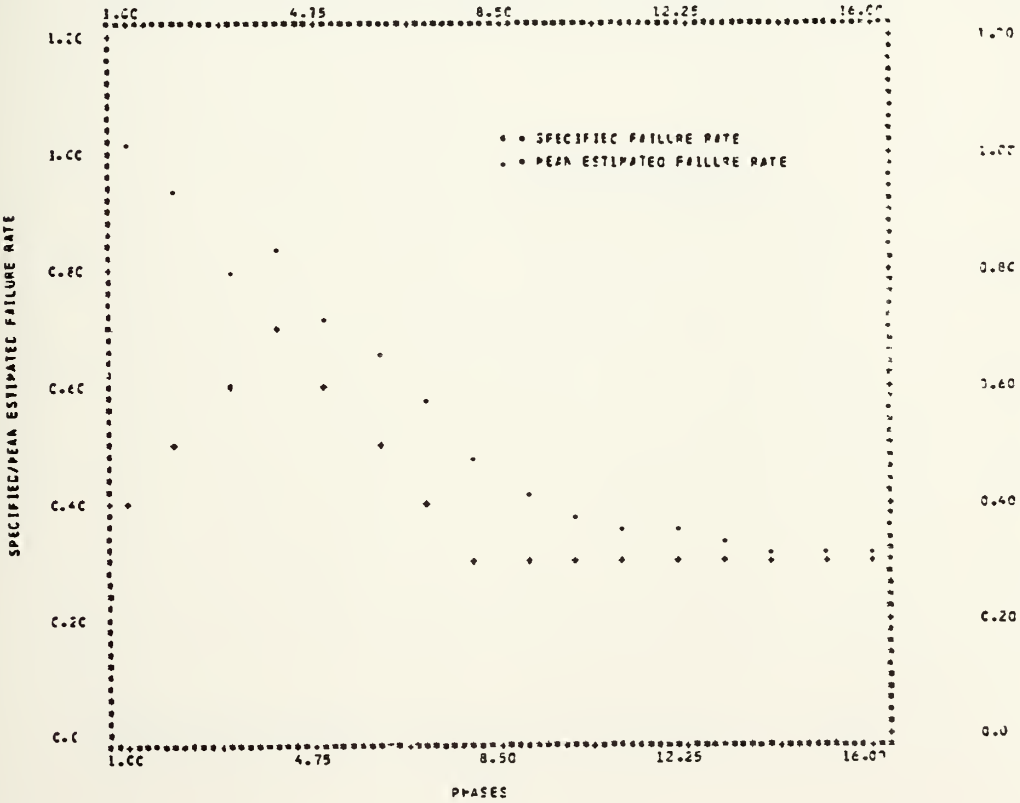


CASE 14

10 ITEMS

```
PHASE                          1         2         3         4         5         6         7         8
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.5000    0.6000    0.7000    0.6000    0.5000    0.4000    0.3000
PLANNED  TEST  TIME       0.4063    0.3250    0.2709    0.2322    0.2709    0.3250    0.4063    0.5417
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.0249    0.9329    0.7954    0.8310    0.7100    0.6545    0.5741    0.4804
ESTIMATE  ERROR  AS       150.23     86.57     32.57     18.71     18.33     30.91     43.53     60.13
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      1.1811    0.8713    0.4991    0.4529    0.3486    0.3173    0.2776    0.2097
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       3.748     6.722     9.225    11.362    13.907    16.916    20.682    25.665
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.5500    3.2200    4.7600    6.3500    7.5400    8.9600   10.4000   11.9200
--------------------------------------------------------------------------------------------------------
```

```
PHASE                          9        10        11        12        13        14        15        16
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.3000    0.3000    0.3000    0.3000    0.3000    0.3000    0.3000    0.3000
PLANNED  TEST  TIME       0.5417    0.5417    0.5417    0.5417    0.5417    0.5417    0.5417    0.5417
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.4192    0.3746    0.3629    0.3511    0.3335    0.3275    0.3236    0.3178
ESTIMATE  ERROR  AS        39.74     24.87     20.96     17.03     11.17      9.16      7.85      5.93
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.1591    0.1346    0.1224    0.1043    0.0947    0.0857    0.0848    0.0819
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      30.701    35.758    40.712    45.666    50.700    55.666    60.678    65.682
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      13.3500   14.6700   16.3000   17.9000   19.3100   20.9100   22.4900   23.9800
--------------------------------------------------------------------------------------------------------
```

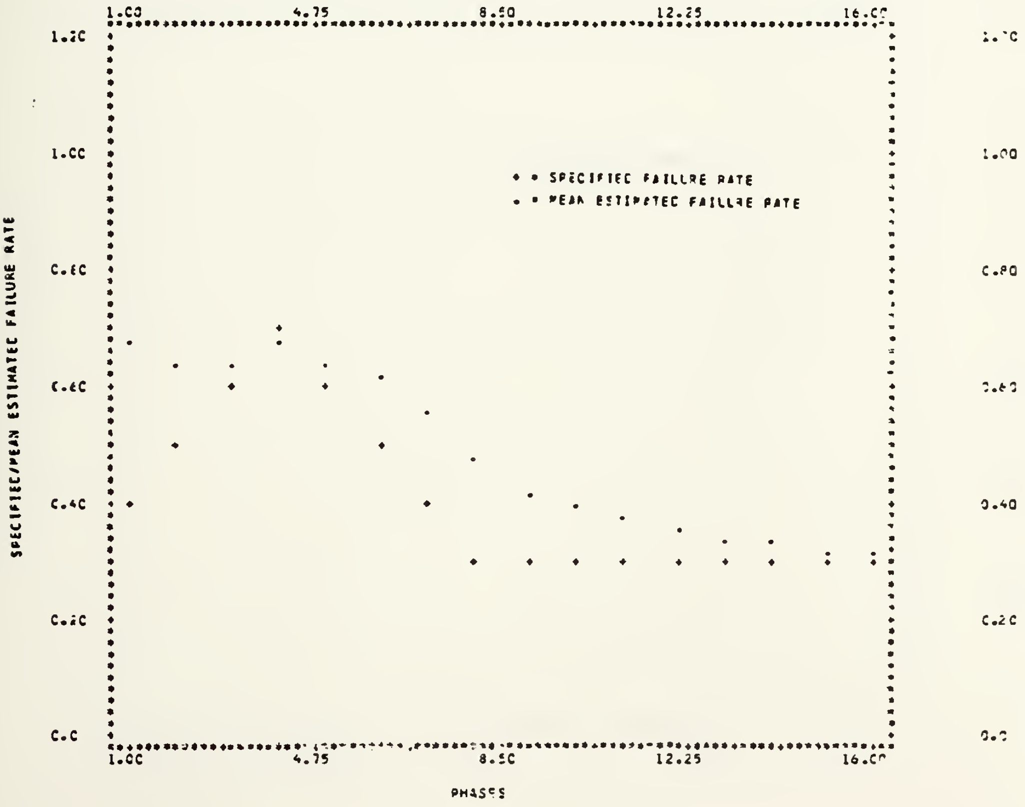


CASE 14

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.4000	0.5000	0.6000	0.7000	0.6000	0.5000	0.4000	0.3000
PLANNED TEST TIME	0.4063	0.3250	0.2709	0.2322	0.2709	0.3250	0.4063	0.5417
MODEL ESTIMATE	0.6868	0.6447	0.6330	0.6711	0.6484	0.6114	0.5569	0.4782
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	71.69	28.93	5.49	4.13	8.06	22.29	39.23	59.39
SAMPLE STD DEVIATION	0.5298	0.4113	0.2714	0.2612	0.2510	0.1863	0.1641	0.1256
CUMULATIVE TEST TIME	7.471	13.447	18.470	22.792	27.821	33.814	41.254	51.174
CUMULATIVE FAILURES	3.1300	6.2100	9.0700	11.8200	14.5800	17.6400	20.8200	24.1300

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
PLANNED TEST TIME	0.5417	0.5417	0.5417	0.5417	0.5417	0.5417	0.5417	0.5417
MODEL ESTIMATE	0.4262	0.3918	0.3705	0.3522	0.3414	0.3312	0.3224	0.3160
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	42.08	30.61	23.50	17.41	13.81	10.39	7.45	5.33
SAMPLE STD DEVIATION	0.1045	0.0925	0.0849	0.0719	0.0686	0.0643	0.0627	0.0651
CUMULATIVE TEST TIME	61.120	71.108	81.071	91.080	101.033	110.972	120.975	130.959
CUMULATIVE FAILURES	27.1500	30.1500	33.2400	36.1800	39.2700	42.2000	45.1300	48.0500



```
                                   CASE 15

                                   5 ITEMS

PHASE                            1         2         3         4         5         6         7         8
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000    0.3000    0.0500    0.5000    0.2000    0.1000    0.4000    0.3000
PLANNED  TEST  TIME         0.2322    0.5417    3.2504    0.3250    0.8126    1.6252    0.4063    0.5417
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            43.2422    0.6972    0.1078    0.3765    0.2858    0.1635    0.1910    0.2181
ESTIMATE  ERROR  AS        6077.45    132.40    115.52     24.71     42.89     63.54     52.26     27.31
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       *******    0.6149    0.1108    0.7281    0.3788    0.1745    0.1773    0.2238
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         1.074     3.573    18.481    19.990    23.722    31.225    33.112    35.575
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.7500    1.5200    2.2500    2.9500    3.7600    4.5200    5.1400    5.9300
---------------------------------------------------------------------------------------------------------

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PHASE                            9        10        11        12        13        14        15        16
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.2000    0.1500    0.3000    0.3000    0.2000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME         0.8126    1.0835    0.5417    0.5417    0.8126    1.6252    1.6252    1.6252
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.2127    0.2011    0.2208    0.2304    0.2295    0.1959    0.1686    0.1518
ESTIMATE  ERROR  AS           6.35     34.08     26.39     23.19     14.76     95.88     68.59     51.81
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.1944    0.1587    0.1710    0.1586    0.1455    0.1124    0.0865    0.0777
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        39.351    44.288    46.786    49.254    53.005    60.464    68.097    75.729
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         6.6500    7.5000    8.3100    9.1700    9.9000   10.7100   11.3500   11.9900
---------------------------------------------------------------------------------------------------------
```
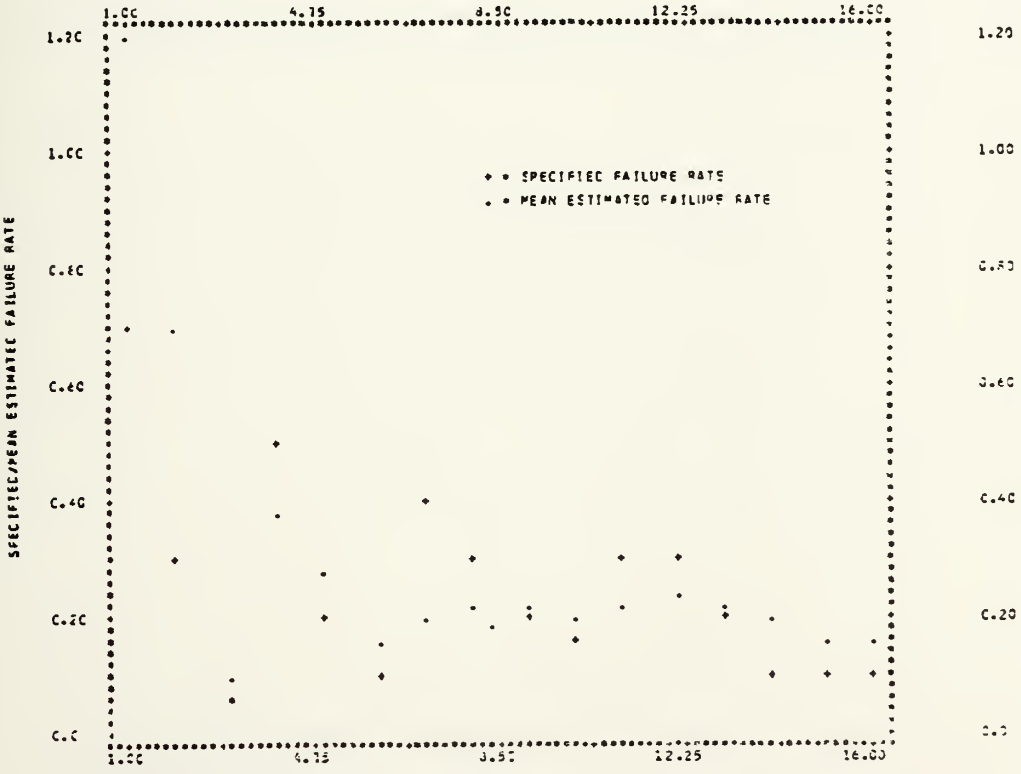



NUMBER OF POINTS OUT OF RANGE = 1

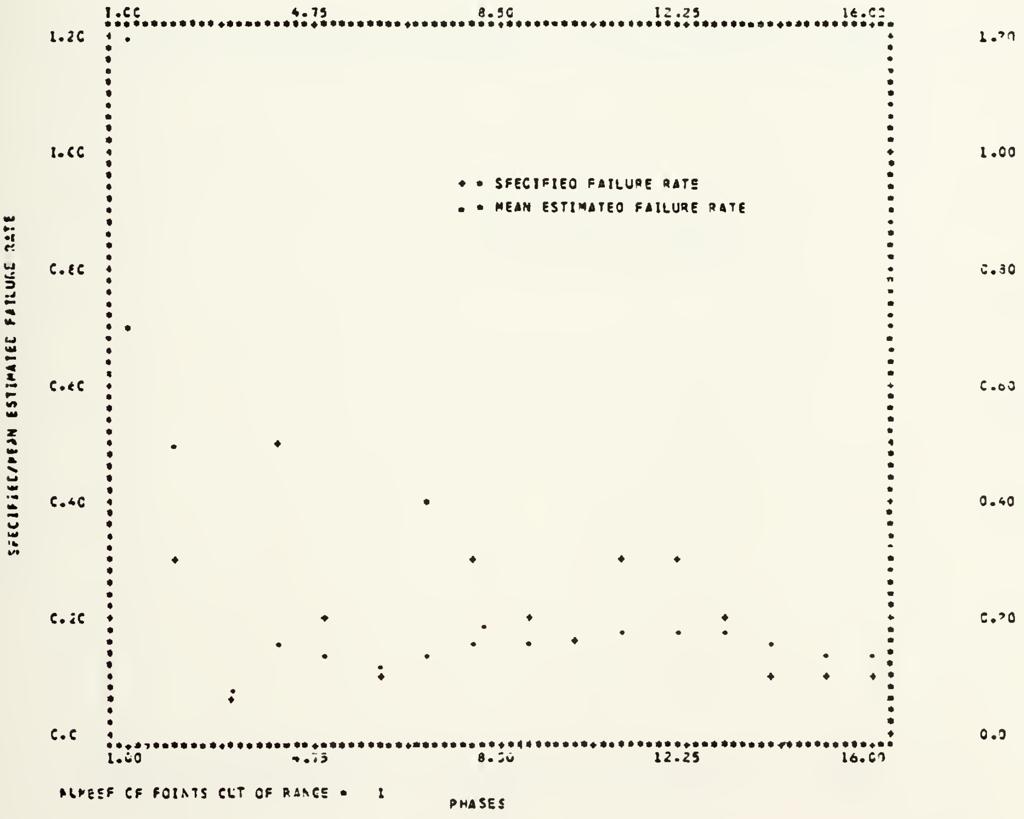
CASE 15

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.3000	0.0500	0.5000	0.2000	0.1000	0.4000	0.3000
PLANNED TEST TIME	0.2322	0.5417	3.2504	0.3750	0.8126	1.6252	0.4063	0.5417
MODEL ESTIMATE	1.6614	0.4941	0.0789	0.1567	0.1448	0.1105	0.1385	0.1541
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	137.34	64.68	57.86	68.67	27.61	10.47	65.36	48.65
SAMPLE STD DEVIATION	1.6267	0.5024	0.1076	0.3366	0.1564	0.0636	0.0857	0.0777
CUMULATIVE TEST TIME	2.104	7.083	37.101	40.105	47.606	62.576	66.304	71.262
CUMULATIVE FAILURES	1.7700	3.3500	4.8900	6.3500	7.9200	9.3600	10.9800	12.5500

* * *

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.2000	0.1500	0.3000	0.3000	0.2000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.8126	1.0835	0.5417	0.5417	0.8126	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.1600	0.1580	0.1742	0.1838	0.1828	0.1622	0.1499	0.1411
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	19.98	5.31	41.94	38.74	8.60	62.15	49.85	41.12
SAMPLE STD DEVIATION	0.0893	0.0838	0.0939	0.0920	0.0822	0.0667	0.0547	0.0520
CUMULATIVE TEST TIME	76.788	88.725	93.707	98.702	106.248	121.305	136.257	151.192
CUMULATIVE FAILURES	13.9500	15.5700	17.1800	18.6800	20.1100	21.6400	23.2900	24.6700



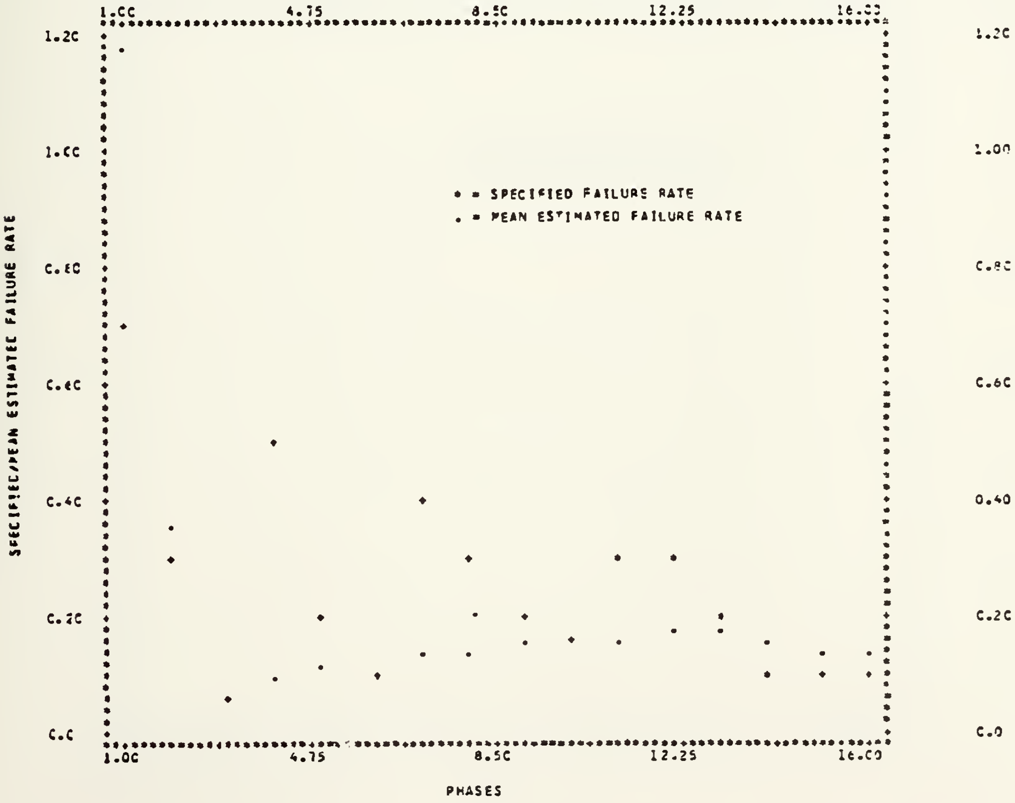
CASE 15

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.3000	0.0500	0.5000	0.2000	0.1000	0.4000	0.3000
PLANNED TEST TIME	0.2322	0.5417	3.2504	0.3250	0.8126	1.6252	0.4063	0.5417
MODEL ESTIMATE	1.1828	0.3503	0.0600	0.0928	0.1123	0.1035	0.1308	0.1500
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	68.98	16.77	19.92	81.45	43.85	3.48	67.30	50.0[illegible]
SAMPLE STD DEVIATION	1.3276	0.1967	0.0259	0.0401	0.0442	0.0357	0.0493	0.0519
CUMULATIVE TEST TIME	4.272	14.288	74.066	80.098	95.034	124.911	132.346	142.278
CUMULATIVE FAILURES	2.9900	5.8500	9.0000	11.7600	14.8800	18.0500	21.3200	24.4500

* * *

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.2000	0.1500	0.3000	0.3000	0.2000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.8126	1.0835	0.5417	0.5417	0.8126	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.1560	0.1532	0.1658	0.1800	0.1817	0.1631	0.1479	0.1378
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	22.01	2.10	44.73	40.01	9.15	63.13	47.85	37.75
SAMPLE STD DEVIATION	0.0518	0.0465	0.0486	0.0463	0.0456	0.0410	0.0332	0.0301
CUMULATIVE TEST TIME	157.243	177.242	187.247	197.196	212.194	242.173	272.258	302.306
CUMULATIVE FAILURES	27.4000	30.4300	33.4100	36.6600	39.6100	42.6600	45.4900	48.4300



```
                                        CASE  16

                                        5 ITEMS

PHASE                        1          2          3          4          5          6          7          8
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000     0.3500     0.3000     0.2500     0.0500     0.0500     0.0500     0.6000
PLANNED  TEST  TIME       0.4063     0.4643     0.5417     0.6501     3.2504     3.2504     3.2504     0.2709
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           2.2716     2.3319     0.5924     0.4192     0.1090     0.0749     0.0596     0.0749
ESTIMATE  ERROR  AS       467.91     566.25      97.46      67.66     118.06      49.76      19.25      87.52
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      4.7638    12.3516     0.5611     0.2693     0.0689     0.0458     0.0371     0.0400
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.878      3.969      6.457      9.450     24.581     39.528     54.650     55.895
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.6300     1.6200     2.3800     3.1900     3.9200     4.6500     5.4300     6.1700
-----------------------------------------------------------------------------------------------------------------

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PHASE                        9         10         11         12         13         14         15         16
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.6000     0.6000     0.5500     0.4000     0.2500     0.1000     0.0500     0.0500
PLANNED  TEST  TIME       0.2709     0.2709     0.2955     0.4063     0.6501     1.6252     3.2504     3.2504
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.0907     0.1168     0.1339     0.1486     0.1601     0.1440     0.1097     0.0910
ESTIMATE  ERROR  AS        84.89      80.53      75.65      62.86      35.97      43.99     119.38      81.99
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.0534     0.0828     0.0629     0.0892     0.0994     0.0793     0.0512     0.0403
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      57.150     58.470     59.730     61.603     64.563     72.116     87.265    102.556
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       6.8500     7.7700     8.5000     9.2300    10.0100    10.6900    11.3100    11.9300
-----------------------------------------------------------------------------------------------------------------
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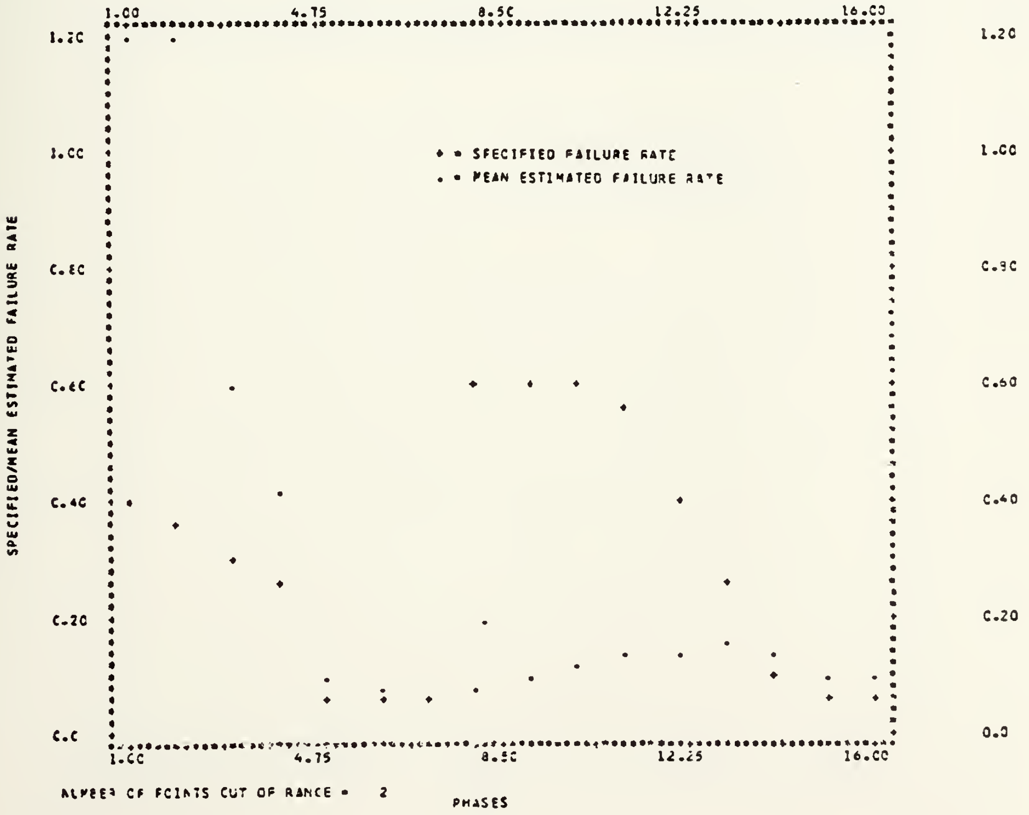

NUMBER OF POINTS OUT OF RANGE =   2

```
                                   CASE  16

                                   10 ITEMS

PHASE                             1         2         3         4         5         6         7         8
--------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.4000    0.3500    0.3000    0.2500    0.0500    0.0500    0.0500    0.6000
PLANNED  TEST  TIME          0.4063    0.4643    0.5417    0.6501    3.2504    3.2504    3.2504    0.2709
--------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              1.3927    0.6009    0.4657    0.3459    0.1024    0.0667    0.0523    0.0645
ESTIMATE  ERROR  AS          248.18     71.69     55.24     38.35    104.88     33.46      4.66     89.24
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         2.2082    0.4395    0.2904    0.1796    0.0450    0.0263    0.0184    0.0246
--------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME          3.724     7.987    12.941    18.954    48.688    78.725   108.938   111.465
--------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          1.6400    3.2700    4.9400    6.4400    8.0500    9.4600   10.7700   12.1100
--------------------------------------------------------------------------------------------------------------

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PHASE                             9        10        11        12        13        14        15        16
--------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.6000    0.6000    0.5500    0.4000    0.2500    0.1000    0.0500    0.0500
PLANNED  TEST  TIME          0.2709    0.2709    0.2955    0.4063    0.6501    1.6252    3.2504    3.2504
--------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              0.0791    0.0960    0.1133    0.1264    0.1347    0.1240    0.1011    0.0870
ESTIMATE  ERROR  AS           86.81     84.00     79.40     68.41     46.12     24.04    102.18     73.95
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         0.0286    0.0357    0.0409    0.0431    0.0438    0.0386    0.0263    0.0220
--------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        113.966   116.459   119.164   122.893   128.903   144.121   173.911   203.609
--------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         13.6500   15.2600   16.3700   18.3700   19.8300   21.1000   22.6700   24.1800
--------------------------------------------------------------------------------------------------------------
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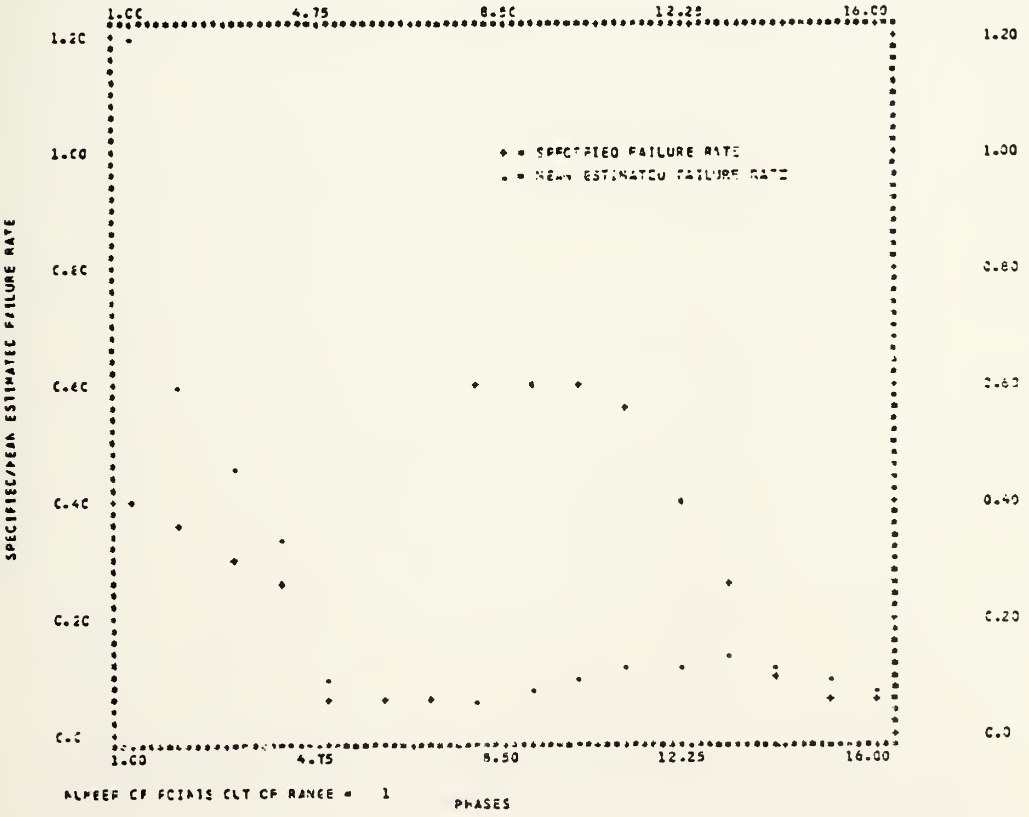

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                                        CASE  16

                                        20 ITEMS

PHASE                          1         2         3         4         5         6         7         8
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.3500    0.3000    0.2500    0.0500    0.0500    0.0500    0.6000
PLANNED  TEST  TIME       0.4063    0.4643    0.5417    0.6501    3.2504    3.2504    3.2504    0.2709
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.5997    0.4452    0.3736    0.3096    0.0908    0.0618    0.0506    0.0637
ESTIMATE  ERROR  AS        49.92     27.19     24.54     23.82     81.51     23.62      1.18     89.38
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.4130    0.2285    0.1584    0.1179    0.0316    0.0183    0.0146    0.0178
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       7.498    16.057    26.036    38.054    98.276   158.310   218.639   223.662
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       3.0000    6.1600    9.3600   12.3800   15.1500   18.1500   20.9600   23.9300
--------------------------------------------------------------------------------------------------------

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PHASE                          9        10        11        12        13        14        15        16
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.6000    0.6000    0.5500    0.4000    0.2500    0.1000    0.0500    0.0500
PLANNED  TEST  TIME       0.2709    0.2709    0.2555    0.4063    0.6501    1.6252    3.2504    3.2504
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.0767    0.0905    0.1064    0.1189    0.1266    0.1190    0.0968    0.0840
ESTIMATE  ERROR  AS        87.21     84.92     80.66     70.26     49.36     18.98     93.57     67.92
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.0193    0.0218    0.0258    0.0276    0.0297    0.0268    0.0209    0.0168
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     228.655   233.718   239.169   246.737   258.833   289.011   349.552   408.775
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      26.7100   29.5700   32.6700   35.5200   38.2800   41.0500   43.9100   46.9500
--------------------------------------------------------------------------------------------------------
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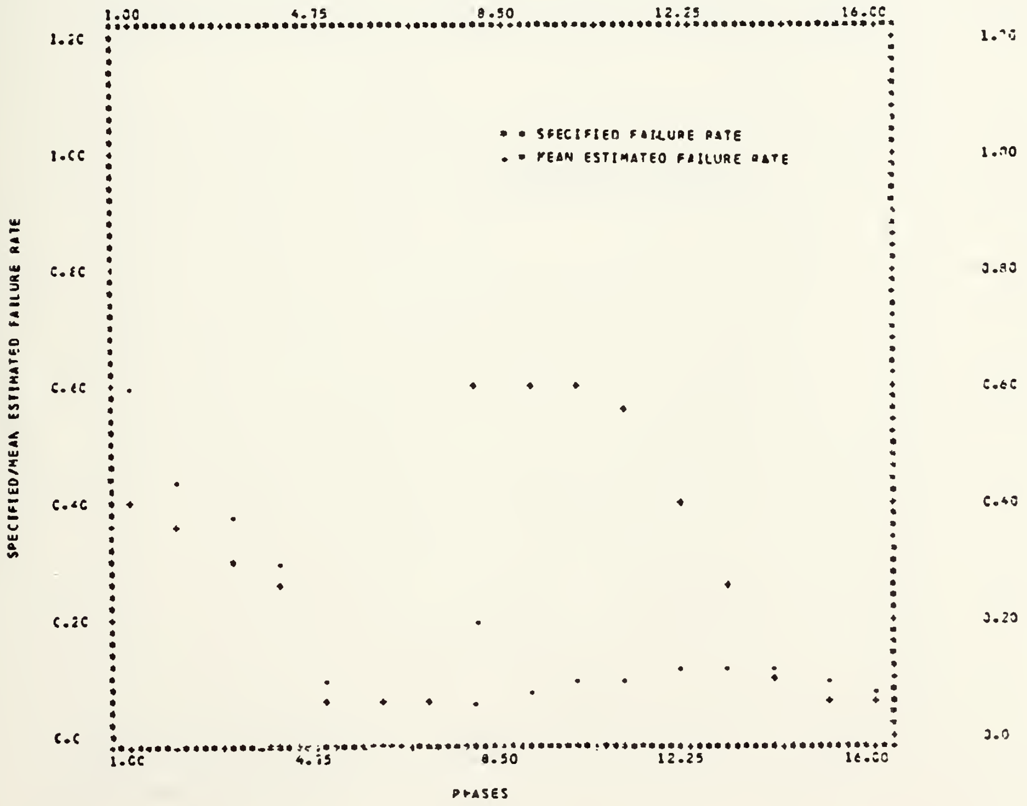
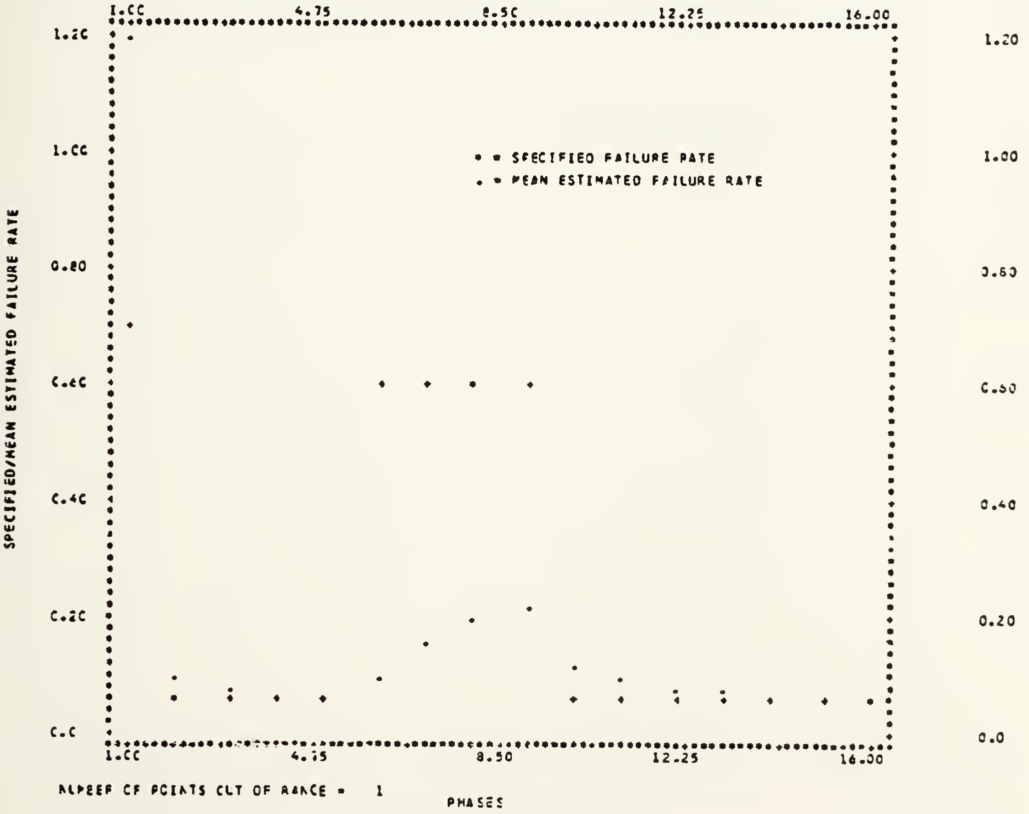


CASE 17

5 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.0500	0.0500	0.0500	0.0500	0.6000	0.6000	0.6000
PLANNED TEST TIME	0.2322	3.2504	3.2504	3.2504	3.2504	0.2709	0.2709	0.2709
MODEL ESTIMATE	3.1219	0.1046	0.0767	0.0553	0.0540	0.1088	0.1657	0.2002
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	345.98	109.20	53.34	10.56	7.96	81.87	72.39	66.64
SAMPLE STD DEVIATION	4.3345	0.1278	0.1014	0.0368	0.0371	0.1726	0.2576	0.4368
CUMULATIVE TEST TIME	1.074	16.100	31.132	46.144	61.089	62.342	63.584	64.847
CUMULATIVE FAILURES	0.7300	1.6500	2.4000	3.1800	3.9800	4.7500	5.5600	6.2300

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.6000	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2709	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.2253	0.1140	0.0939	0.0803	0.0722	0.0690	0.0672	0.0632
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	62.44	128.08	87.77	60.56	44.43	37.91	34.37	26.31
SAMPLE STD DEVIATION	0.4564	0.0799	0.0561	0.0404	0.0328	0.0311	0.0297	0.0259
CUMULATIVE TEST TIME	66.090	81.203	95.926	110.912	125.809	140.723	155.588	170.701
CUMULATIVE FAILURES	7.0100	7.7100	8.5400	9.2800	10.0300	10.8300	11.7400	12.4900

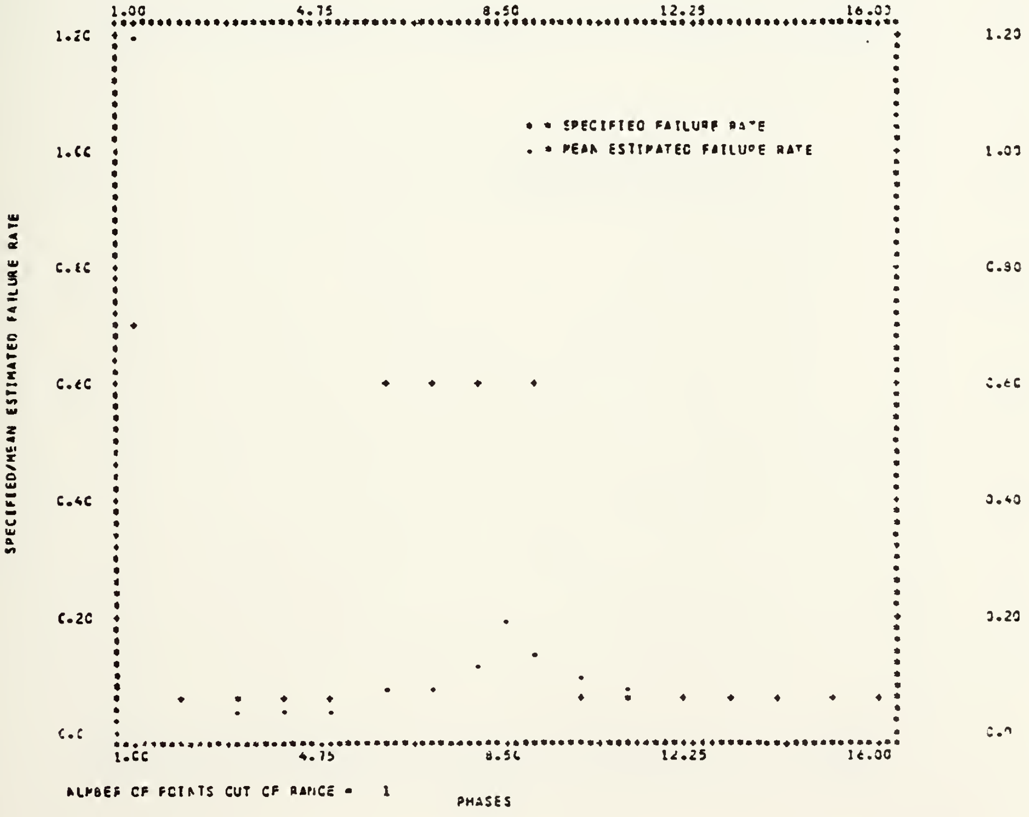


CASE 17

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.0500	0.0500	0.0500	0.0500	0.6000	0.6000	0.6000
PLANNED TEST TIME	0.2322	3.2504	3.2504	3.2504	3.2504	0.2709	0.2709	0.2709
MODEL ESTIMATE	1.8160	0.0566	0.0405	0.0444	0.0445	0.0707	0.0897	0.1162
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	159.43	13.12	19.01	11.24	11.08	88.21	85.04	80.64
SAMPLE STD DEVIATION	3.5101	0.0580	0.0252	0.0368	0.0333	0.0960	0.1254	0.1991
CUMULATIVE TEST TIME	2.147	32.677	62.841	92.878	122.973	125.490	128.010	130.535
CUMULATIVE FAILURES	1.4200	2.6500	4.1200	5.6300	7.1400	8.5900	9.8700	11.1900

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.6000	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.2709	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.1420	0.0933	0.0783	0.0692	0.0651	0.0609	0.0579	0.0550
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	76.34	86.68	56.53	38.39	30.16	21.79	15.73	10.08
SAMPLE STD DEVIATION	0.2162	0.0514	0.0361	0.0275	0.0237	0.0220	0.0199	0.0168
CUMULATIVE TEST TIME	133.023	163.148	193.286	223.606	253.301	283.464	313.431	343.632
CUMULATIVE FAILURES	12.7400	14.2100	15.5900	17.0100	18.6400	19.9900	21.4200	22.8200



NUMBER OF POINTS OUT OF RANGE = 1

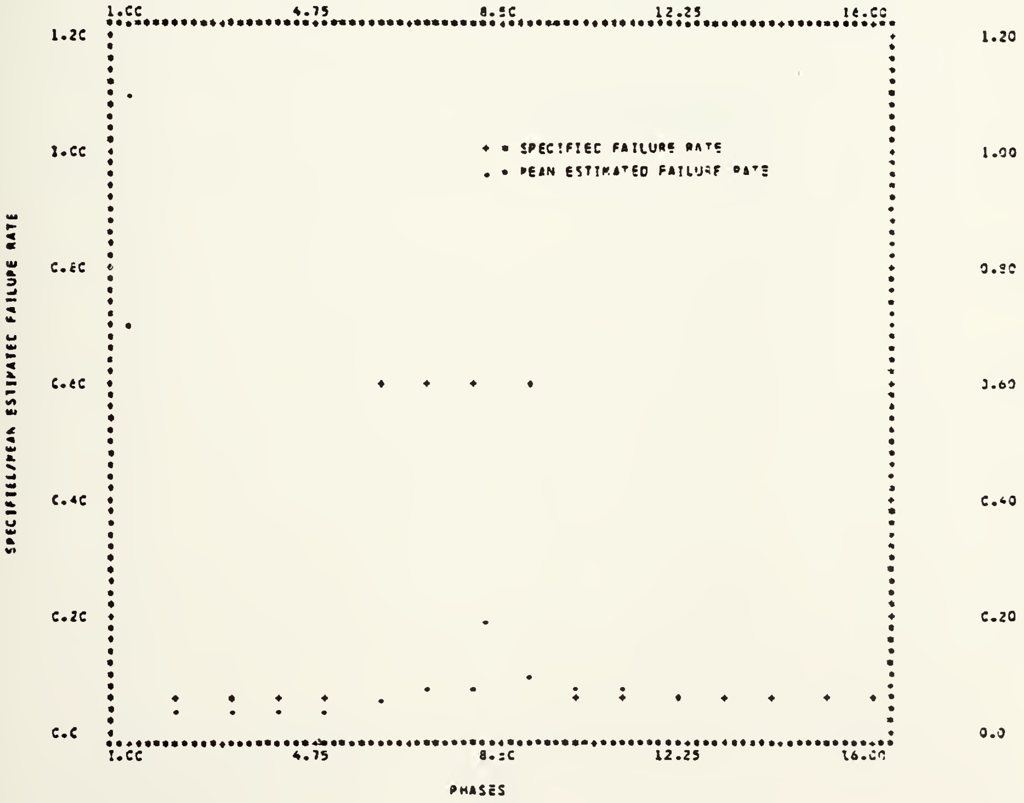
```
                                      CASE  17

                                      20 ITERS

PHASE                         1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000    0.0500    0.0500    0.0500    0.0500    0.6000    0.6000    0.6000
PLANNED  TEST  TIME      0.2322    3.2504    3.2504    3.2504    3.2504    0.2709    0.2709    0.2709
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          1.0539    0.0455    0.0398    0.0379    0.0373    0.0533    0.0709    0.0886
ESTIMATE  ERROR  AS       56.27      0.58     20.45     24.12     25.47     91.12     68.15     85.23
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     1.0963    0.0273    0.0214    0.0182    0.0144    0.0231    0.0304    0.0372
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      4.301    64.276   124.450   184.981   245.142   250.164   255.160   260.155
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      2.9200    6.0200    8.8500   11.8100   14.7000   17.7500   20.7900   23.6700
------------------------------------------------------------------------------------------------------

..............................................................................................................

PHASE                         9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.6000    0.0500    0.0500    0.0500    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME      0.2709    3.2504    3.2504    3.2504    3.2504    3.2504    3.2504    3.2504
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.1058    0.0868    0.0755    0.0682    0.0637    0.0591    0.0571    0.0550
ESTIMATE  ERROR  AS       82.36     73.63     50.98     36.43     27.31     18.26     14.11     10.07
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.0413    0.0298    0.0232    0.0194    0.0164    0.0146    0.0134    0.0123
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME    265.205   325.017   385.302   445.457   505.314   565.918   625.928   685.722
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     26.3900   29.4800   32.5000   35.4700   38.5600   41.2500   44.3800   47.3300
------------------------------------------------------------------------------------------------------
```

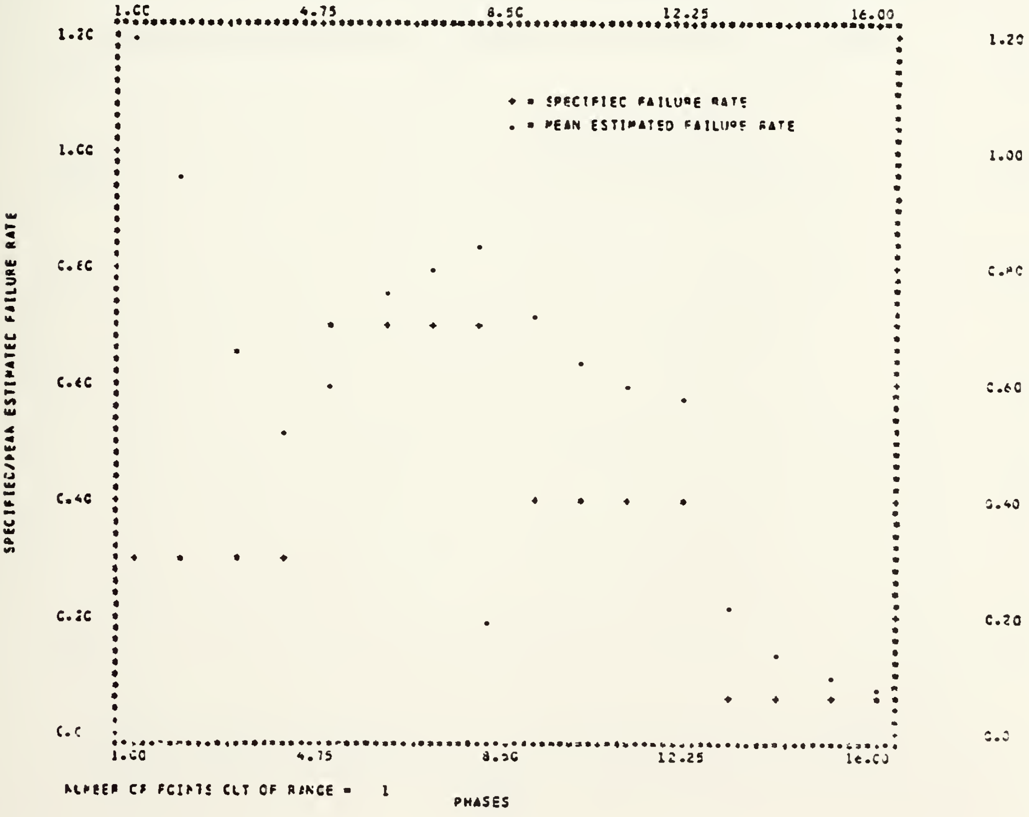


CASE 18

5 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.5417	0.5417	0.5417	0.5417	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	1.8200	0.9681	0.6653	0.5246	0.6056	0.7648	0.7908	0.8333
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	506.67	222.69	121.78	74.86	13.45	9.26	12.97	19.04
SAMPLE STD DEVIATION	4.7804	2.3516	0.7554	0.5059	0.6397	0.6660	0.5736	0.6003
CUMULATIVE TEST TIME	2.509	5.042	7.507	10.020	11.119	12.158	13.223	14.288
CUMULATIVE FAILURES	0.7100	1.4200	2.2600	2.9400	3.5000	4.4700	5.3700	6.1000

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.7238	0.6428	0.5941	0.5712	0.2266	0.1403	0.1027	0.0841
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	80.94	60.69	48.51	42.79	353.20	180.61	105.42	68.28
SAMPLE STD DEVIATION	0.5225	0.3726	0.3149	0.2982	0.0908	0.0485	0.0350	0.0230
CUMULATIVE TEST TIME	16.166	18.057	19.941	21.804	36.765	51.970	67.164	82.335
CUMULATIVE FAILURES	6.8200	7.5300	8.2700	9.0700	9.9200	10.4000	11.2000	11.9100



NUMBER OF POINTS OUT OF RANGE = 1

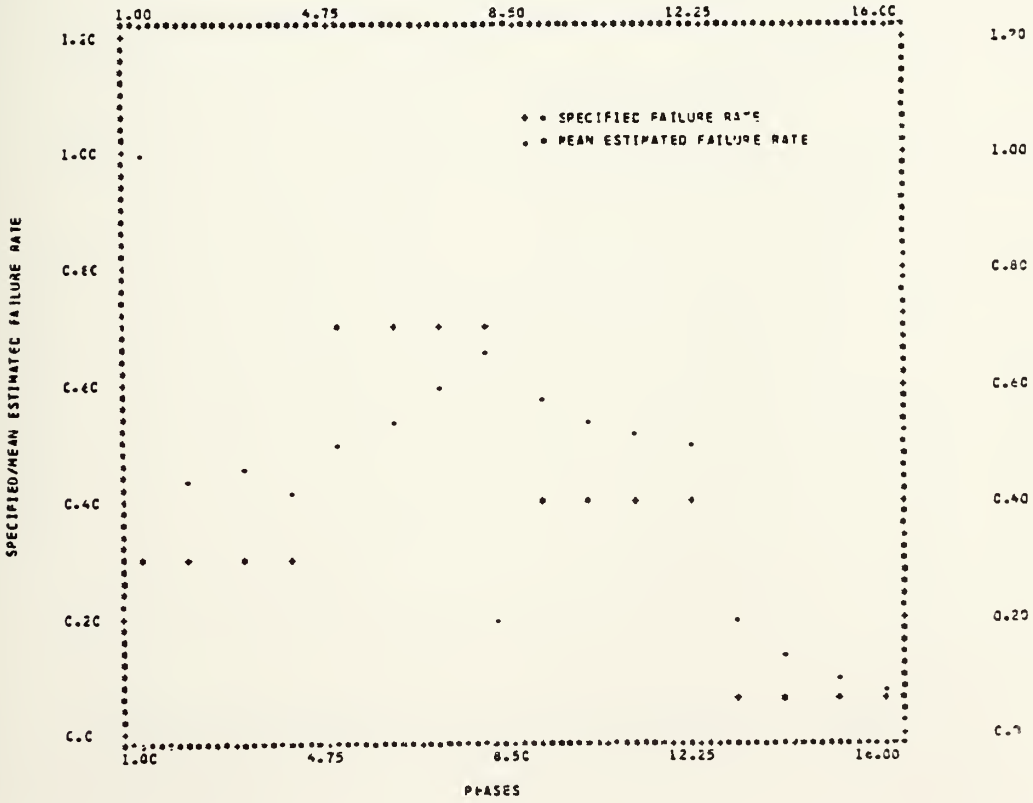
CASE 18

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.5417	0.5417	0.5417	0.5417	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	0.9924	0.4354	0.4509	0.4141	0.4922	0.5417	0.6050	0.6507
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	230.81	45.14	50.31	38.03	29.69	22.61	13.57	7.05
SAMPLE STD DEVIATION	1.8064	0.3275	0.3510	0.2213	0.2896	0.3006	0.3457	0.3053
CUMULATIVE TEST TIME	4.927	9.932	14.858	19.747	21.909	24.061	26.213	28.341
CUMULATIVE FAILURES	1.5900	3.0400	4.7600	6.5600	7.9700	9.3200	10.8400	12.4700

……

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.5856	0.5325	0.5184	0.5015	0.2063	0.1326	0.1004	0.0829
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	46.41	33.12	29.61	25.38	312.54	165.13	100.70	65.73
SAMPLE STD DEVIATION	0.2372	0.1869	0.1858	0.1604	0.0580	0.0421	0.0282	0.0230
CUMULATIVE TEST TIME	32.125	35.950	39.705	43.459	73.610	103.736	133.755	163.986
CUMULATIVE FAILURES	13.8200	15.0600	16.5500	18.0700	19.4800	20.8400	22.3300	23.8200



```
                                          CASE  18

                                          20 ITEMS

PHASE                          1          2          3          4          5          6          7          8
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.3000     0.3000     0.3000     0.3000     0.7000     0.7000     0.7000     0.7000
PLANNED  TEST  TIME         0.5417     0.5417     0.5417     0.5417     0.2322     0.2322     0.2322     0.2322
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.4793     0.3668     0.3657     0.3373     0.4107     0.4909     0.5454     0.5880
ESTIMATE  ERROR  AS          59.77      22.28      21.89      12.43      41.32      29.88      22.08      16.01
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.4000     0.2244     0.1727     0.1377     0.1405     0.1751     0.1985     0.1904
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         9.996     19.986     29.890     39.908     44.206     48.475     52.744     57.039
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         3.0300     5.9000     9.1800    12.0600    14.9400    18.1200    21.0300    23.9500
------------------------------------------------------------------------------------------------------------


***************************************************************************************************************


PHASE                          9         10         11         12         13         14         15         16
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.4000     0.4000     0.4000     0.4000     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME         0.4063     0.4063     0.4063     0.4063     3.2504     3.2504     3.2504     3.2504
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.5520     0.5296     0.5202     0.5038     0.2070     0.1310     0.1005     0.0825
ESTIMATE  ERROR  AS          38.01      32.40      30.04      25.95     314.09     161.90     100.99      65.08
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.1544     0.1518     0.1315     0.1207     0.0415     0.0237     0.0184     0.0139
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        64.569     72.091     79.547     87.097    147.563    208.236    267.736    327.823
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        26.9100    29.8600    33.1100    36.0300    38.8700    41.9400    44.6200    47.5000
------------------------------------------------------------------------------------------------------------
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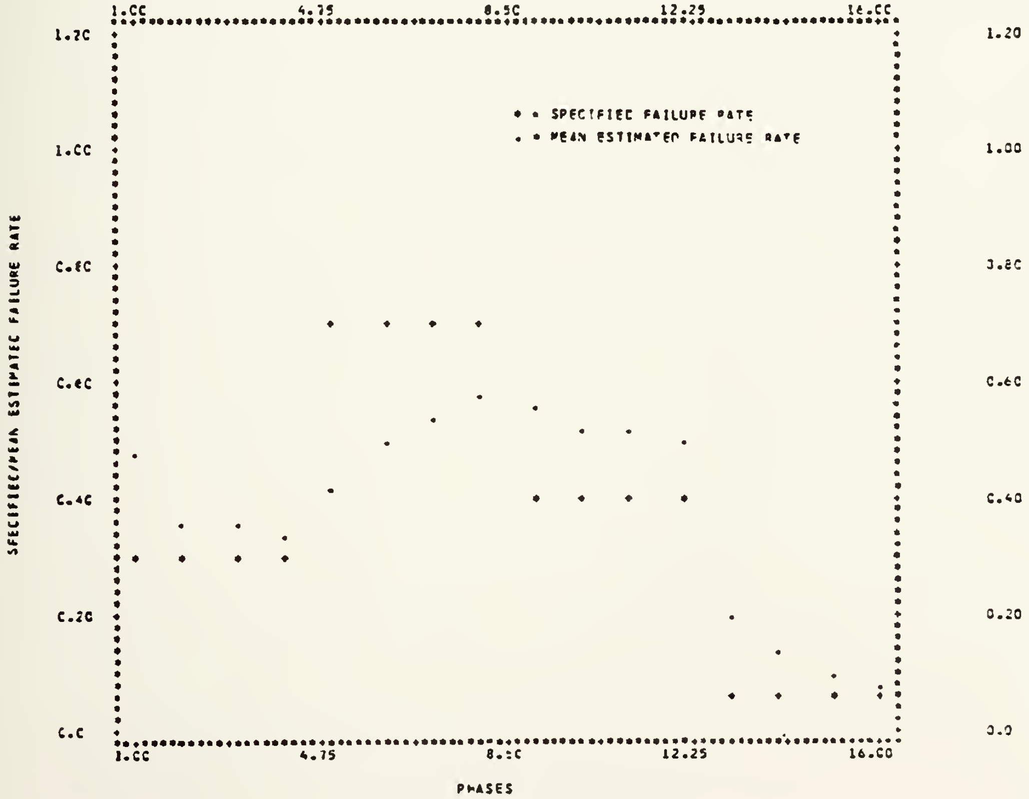


APPENDIX B

Results of Test 2

This appendix contains the results for Cases 1, 3, 7, and 18. The planned test times were generated for a probability of survival of .99.

A detailed description of the format of the results can be found in Appendix A.

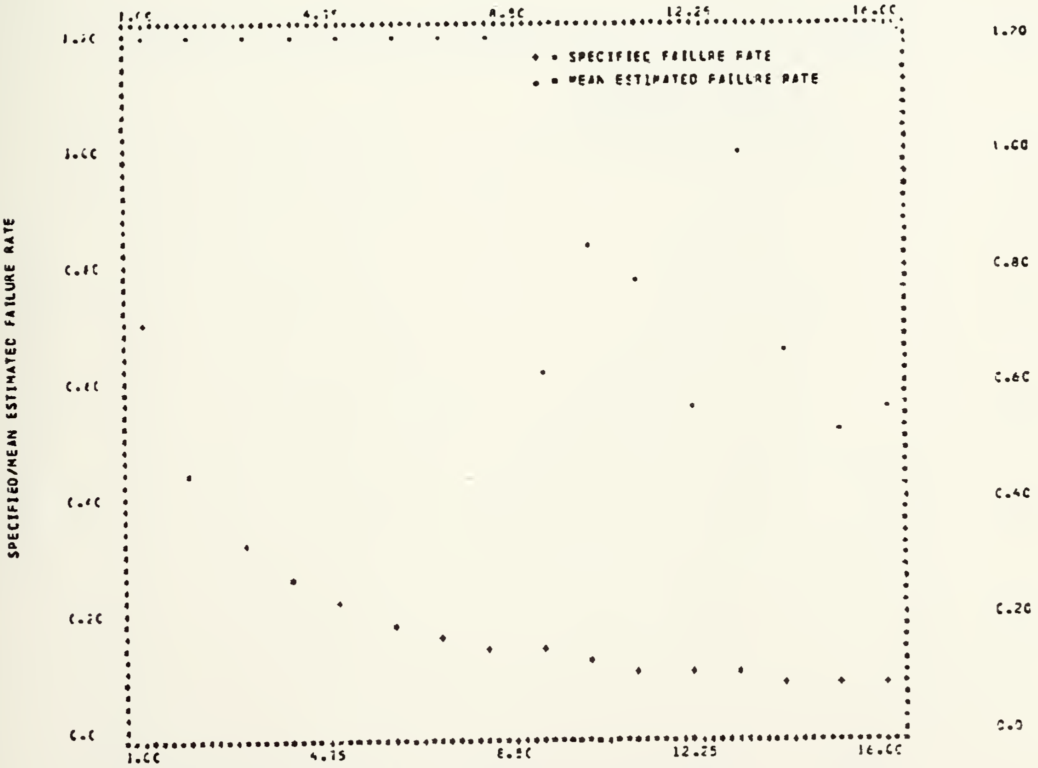
```
                                          CASE   1

                                          5 ITEMS

PHASE                         1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7020    0.4340    0.3200    0.2550    0.2130    0.1830    0.1610    0.1440
PLANNED  TEST  TIME       0.0143    0.0232    0.0314    0.0394    0.0472    0.0549    0.0624    0.0698
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          31.8283   16.3034    5.3956    3.7270    3.6502    2.4186    1.2357    1.3603
ESTIMATE  ERROR  AS      4433.54   3656.53   1586.12   1361.57   1613.71   1221.66    667.53    844.63
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     26.7755   18.6836    5.3205    3.5890    5.1768    4.2812    1.2061    1.9651
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       0.071     0.187     0.343     0.539     0.774     1.049     1.359     1.707
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.0300    0.0600    0.0900    0.1300    0.1800    0.2100    0.2300    0.2800
------------------------------------------------------------------------------------------------------


..................................................................................................................


PHASE                         9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.1330    0.1180    0.1090    0.1010    0.0936    0.0876    0.0823    0.0776
PLANNED  TEST  TIME       0.0756    0.0852    0.0922    0.0995    0.1074    0.1147    0.1221    0.1288
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.6293    0.8411    0.7862    0.5501    0.9903    0.6564    0.5116    0.5547
ESTIMATE  ERROR  AS       373.15    612.81    621.28    444.63    957.98    649.32    521.62    614.80
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.5297    1.0848    1.2175    0.7225    2.9628    1.4884    1.3351    0.9917
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.085     2.510     2.969     3.466     4.001     4.572     5.182     5.826
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.2900    0.3300    0.3600    0.3800    0.4300    0.4700    0.4800    0.5300
------------------------------------------------------------------------------------------------------
```



NUMBER OF POINTS OUT OF RANGE =   8

PHASES

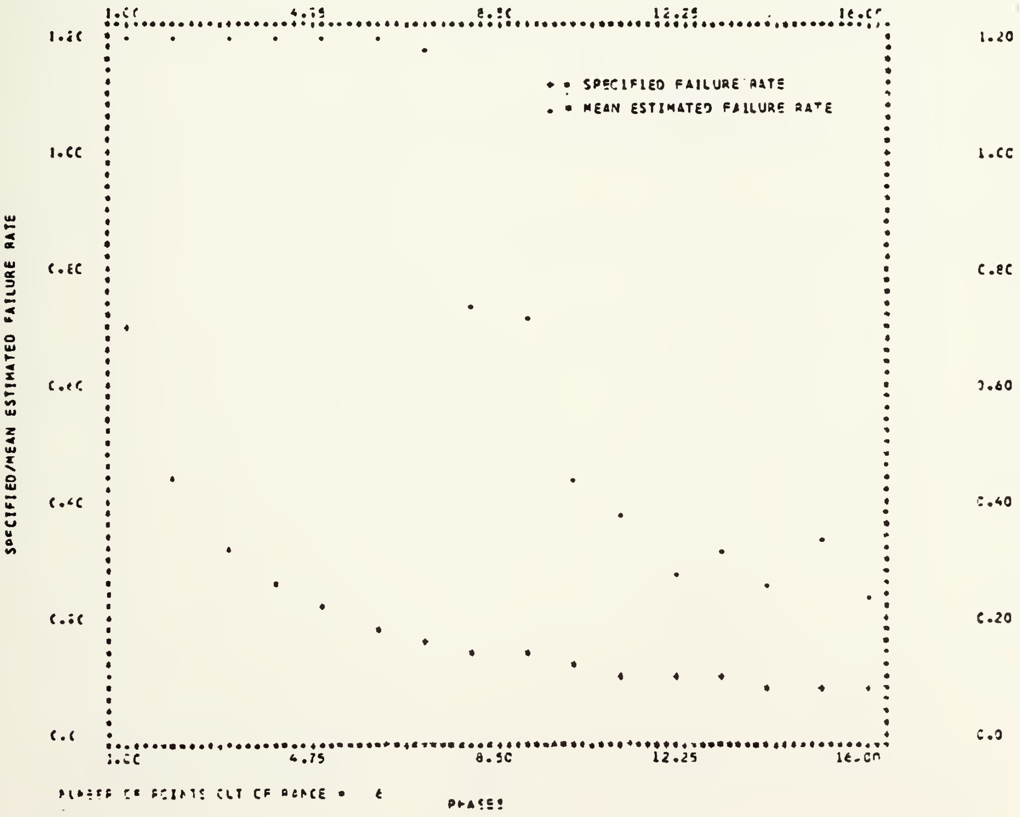
```
                                        CASE  1

                                        10 ITEMS

PHASE                          1         2         3         4         5         6         7         8
-------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7020    0.4340    0.3200    0.2550    0.2130    0.1830    0.1610    0.1440
PLANNED  TEST  TIME         0.0143    0.0232    0.0314    0.0394    0.0472    0.0545    0.0624    0.0696
-------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            16.3315    3.8230    2.7172    1.4539    1.3889    1.3854    1.1818    0.7345
ESTIMATE  ERROR  AS        2226.45    780.68    749.14    470.15    552.06    657.06    634.03    410.07
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       17.4622    3.8113    3.3190    1.7987    2.3278    2.5683    2.5258    1.9261
-------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         0.142     0.373     0.685     1.078     1.548     2.094     2.716     3.411
-------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.1100    0.2100    0.3200    0.3700    0.4700    0.6000    0.6800    0.7700
-------------------------------------------------------------------------------------------------------

*************************************************************************************************************

PHASE                          9        10        11        12        13        14        15        16
-------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.1330    0.1180    0.1090    0.1010    0.0936    0.0876    0.0823    0.0776
PLANNED  TEST  TIME         0.0756    0.0852    0.0922    0.0995    0.1074    0.1147    0.1221    0.1295
-------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.7105    0.4429    0.3854    0.2846    0.3194    0.2536    0.3424    0.2326
ESTIMATE  ERROR  AS         434.22    275.37    253.59    181.83    241.22    189.54    315.99    199.77
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        1.2661    0.4964    0.6959    0.2998    0.9723    0.2335    0.8563    0.2853
-------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         4.160     5.007     5.926     6.915     7.978     9.119    10.332    11.620
-------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.9400    1.0300    1.1200    1.2200    1.3800    1.5100    1.6300    1.7500
-------------------------------------------------------------------------------------------------------
```



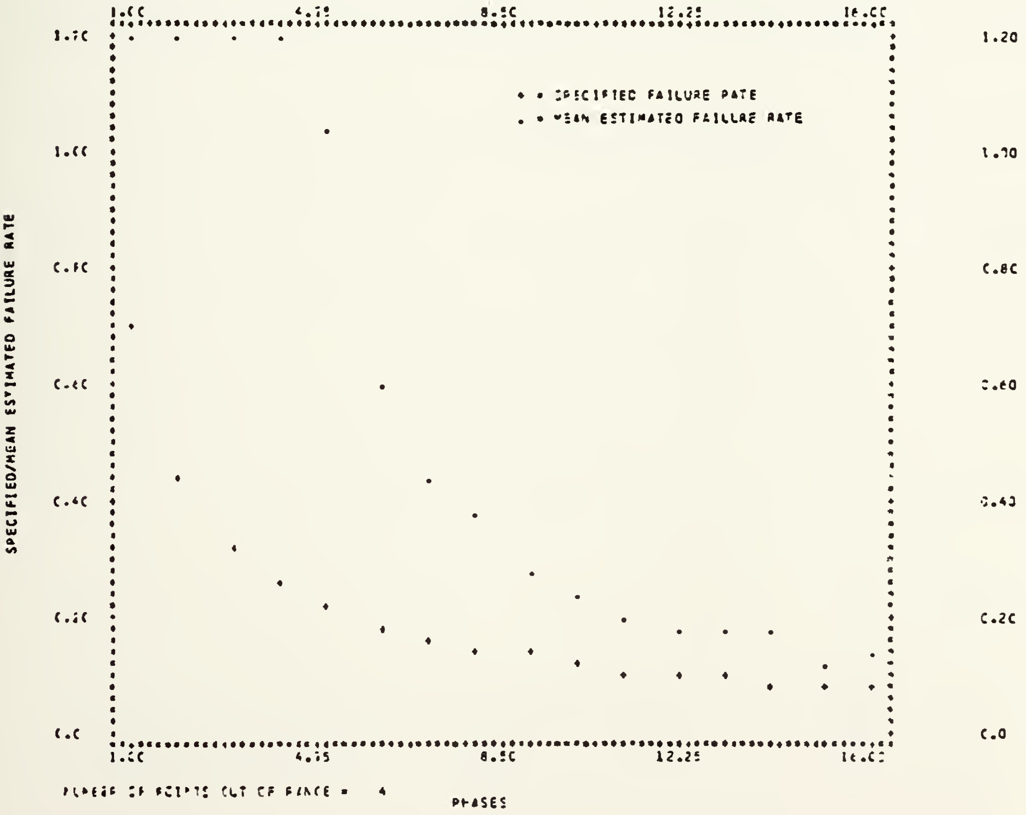
```
                                   CASE  1

                                   20 ITEMS

PHASE                       1        2        3        4        5        6        7        8
--------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7020   0.4340   0.3200   0.2550   0.2130   0.1830   0.1610   0.1440
PLANNED  TEST  TIME      0.0143   0.0232   0.0314   0.0394   0.0472   0.0549   0.0624   0.0698
--------------------------------------------------------------------------------------------
MODEL  ESTIMATE          7.3817   4.9436   1.9522   3.0595   1.0386   0.6045   0.4370   0.3706
ESTIMATE  ERROR  AS      951.52  1039.09   510.06  1099.82   387.60   230.35   171.43   157.36
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    11.2972   9.8599   2.8569  10.9748   3.5188   0.7323   0.4329   0.7662
--------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      0.285    0.749    1.368    2.149    3.087    4.176    5.417    6.808
--------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      0.2500   0.4700   0.7300   1.0800   1.3200   1.5500   1.8300   1.9500
--------------------------------------------------------------------------------------------

*******************************************************************************************************

PHASE                       9       10       11       12       13       14       15       16
--------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.1330   0.1180   0.1090   0.1010   0.0936   0.0876   0.0823   0.0776
PLANNED  TEST  TIME      0.0756   0.0832   0.0922   0.0995   0.1074   0.1147   0.1221   0.1295
--------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.2842   0.2334   0.2039   0.1782   0.1707   0.1773   0.1241   0.1315
ESTIMATE  ERROR  AS      113.71    97.81    87.07    76.48    82.36   102.39    50.79    69.44
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.4394   0.2417   0.2368   0.2140   0.2420   0.4362   0.0971   0.1771
--------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      8.312   10.006   11.844   13.824   15.960   18.246   20.675   23.250
--------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      2.1800   2.4300   2.5800   2.7700   3.0100   3.1800   3.3500   3.6200
--------------------------------------------------------------------------------------------
```



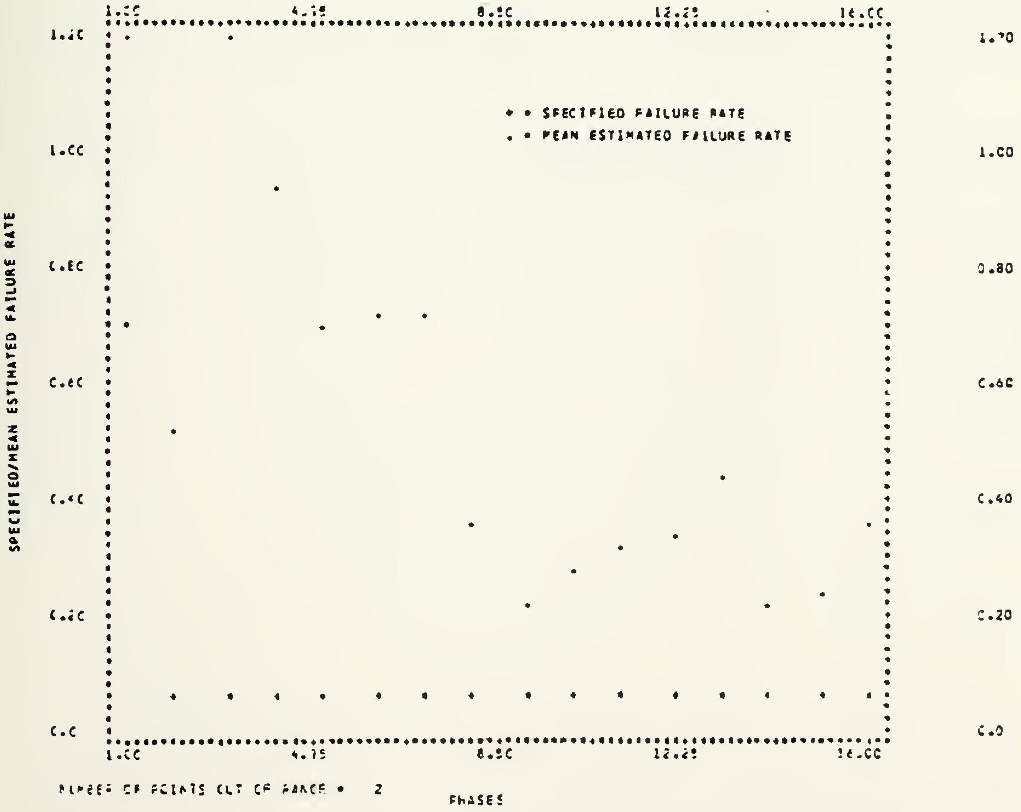
```
                                              CASE   3

                                              5 ITEMS

PHASE                         1          2          3          4          5          6          7          8
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
ELAPSED  TEST  TIME      0.0144     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         32.0856     0.3139     1.9666     0.9339     0.7089     0.7113     0.7209     0.3552
ESTIMATE  ERROR  AS     4483.65     527.78    3833.15    1767.81    1317.82    1322.65    1341.74     610.50
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    27.0078     0.3728     4.5185     1.4566     1.0875     1.0373     1.1814     0.3305
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      0.072      1.075      2.070      3.067      4.068      5.062      6.061      7.062
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      0.0500     0.0800     0.1600     0.2300     0.2700     0.3600     0.4300     0.4600
-----------------------------------------------------------------------------------------------------------


*************************************************************************************************************

PHASE                         9         10         11         12         13         14         15         16
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
ELAPSED  TEST  TIME      0.2010     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.2201     0.2776     0.3228     0.3424     0.4301     0.2221     0.2412     0.3636
ESTIMATE  ERROR  AS      340.23     455.10     545.55     584.87     760.16     344.18     382.37     627.22
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.1745     0.4573     0.8021     0.4751     0.8258     0.2087     0.3835     0.7954
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      8.067      9.068     10.070     11.069     12.068     13.065     14.067     15.070
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      0.4700     0.5200     0.5600     0.6400     0.7100     0.7500     0.7500     0.8700
-----------------------------------------------------------------------------------------------------------
```



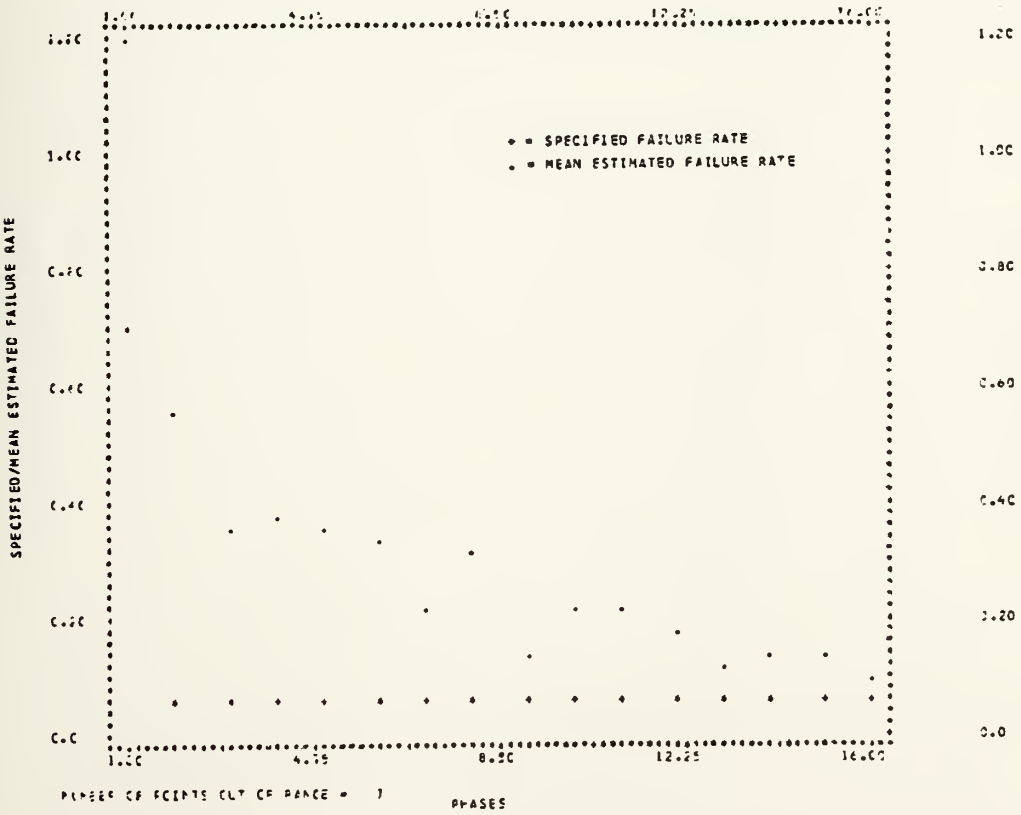
```
                                             CASE   3

                                             10 ITEMS

PHASE                           1          2          3          4          5          6          7          8
----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.7000     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME        0.0144     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010
----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           21.3252     0.5628     0.3642     0.3768     0.3535     0.3433     0.2254     0.3172
ESTIMATE  ERROR  AS      2947.03    1025.50     628.43     653.64     606.92     586.55     350.88     534.42
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      19.1402     1.0382     0.5002     0.5325     0.5064     0.6032     0.3710     0.8074
----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        0.143      2.142      4.140      6.135      8.134     10.126     12.128     14.128
----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        0.1300     0.2200     0.3400     0.4600     0.6100     0.7600     0.8600     0.9400
----------------------------------------------------------------------------------------------------------------

************************************************************************************************************************

PHASE                           9         10         11         12         13         14         15         16
----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME        0.2010     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010     0.2010
----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            0.1458     0.2130     0.2102     0.1847     0.1244     0.1321     0.1400     0.0994
ESTIMATE  ERROR  AS        191.58     325.94     320.48     269.46     148.88     164.19     179.95      98.72
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.1736     0.9055     0.4478     0.5876     0.1471     0.2141     0.2916     0.0995
----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       16.133     18.132     20.130     22.131     24.129     26.126     28.126     30.127
----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        1.0100     1.0900     1.2200     1.3000     1.4400     1.5700     1.6800     1.7600
----------------------------------------------------------------------------------------------------------------
```



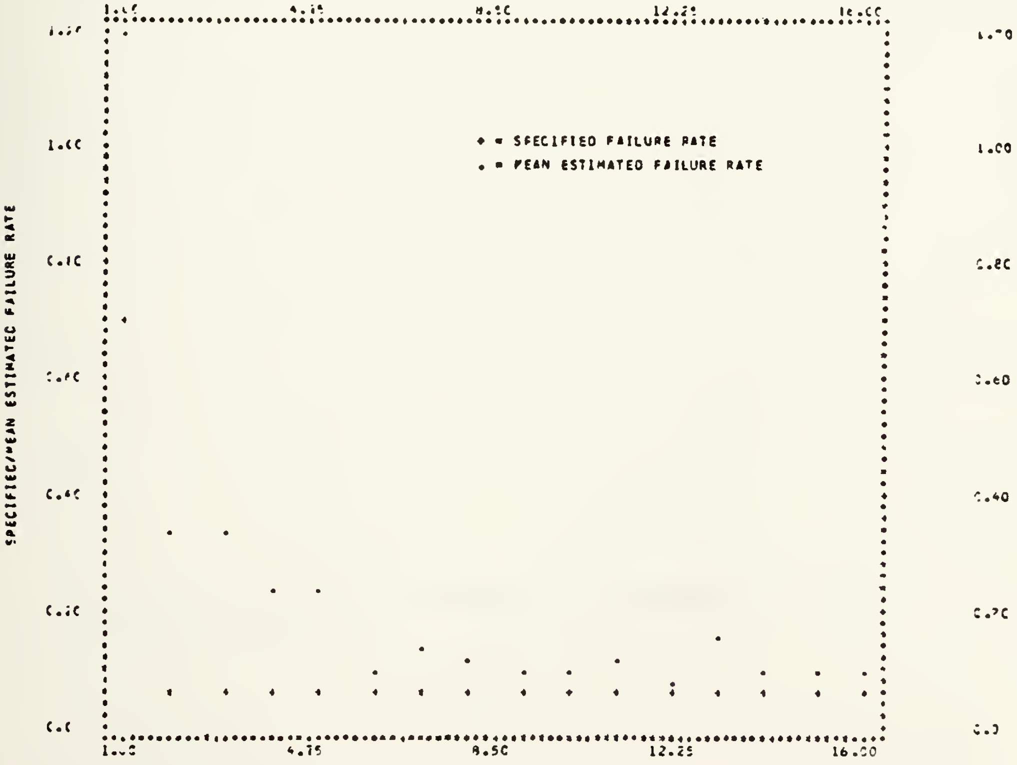
```
                                        CASE   3

                                        20 ITEMS

PHASE                            1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000    0.0500    0.0500    0.0500    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME         0.0144    0.2010    0.2010    0.2010    0.2010    0.2010    0.2010    0.2010
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             5.4676    0.3441    0.3305    0.2375    0.2337    0.1058    0.1454    0.1124
ESTIMATE  ERROR  AS        1252.91    588.17    560.55    374.57    367.46    111.65    190.80    124.83
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       10.0111    0.3755    0.5101    0.3180    0.1025    0.1281    0.2852    0.1771
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         0.266     4.284     8.285    12.280    16.289    20.292    24.288    28.292
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.1100    0.4100    0.6100    0.8500    0.9400    1.1000    1.2800    1.4500
------------------------------------------------------------------------------------------------------------

..............................................................................................................

PHASE                            9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.0500    0.0500    0.0500    0.0500    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME         0.2010    0.2010    0.2010    0.2010    0.2010    0.2010    0.2010    0.2010
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.0945    0.0951    0.1205    0.0886    0.1682    0.0948    0.1048    0.0996
ESTIMATE  ERROR  AS          89.15     90.24    141.01     77.27    236.47     89.51    109.60     99.29
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.1150    0.1263    0.1555    0.0574    0.5486    0.1229    0.2768    0.2069
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        32.296    36.295    40.288    44.295    48.278    52.288    56.290    60.287
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         1.6000    1.8000    2.1100    2.2400    2.6000    2.7300    2.9000    3.1600
------------------------------------------------------------------------------------------------------------
```

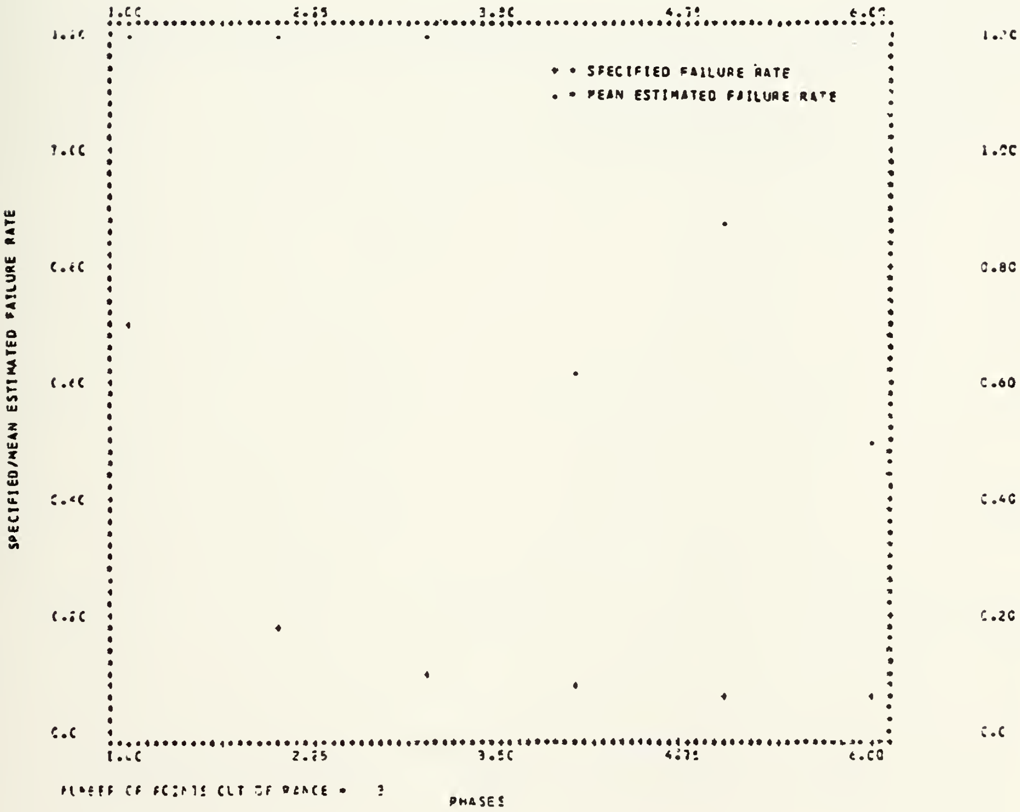


NUMBER OF POINTS OUT OF RANGE = 1

CASE 7

5 ITEMS

```
PHASE                          1         2         3         4         5         6
-----------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.1800    0.1060    0.0760    0.0600    0.0500
PLANNED  TEST  TIME       0.0144    0.0556    0.0548    0.1322    0.1675    0.2010
-----------------------------------------------------------------------------------
MODEL  ESTIMATE          15.8422    4.7837    1.3617    0.6275    0.8815    0.5009
ESTIMATE  ERROR  AS      2734.59   2557.43   1164.58    725.66   1365.16    901.74
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     10.4311    6.5765    1.5440    0.4792    0.5550    0.4631
-----------------------------------------------------------------------------------
CUMULATIVE TEST TIME       0.072     0.350     0.822     1.482     2.316     3.318
-----------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.0300    0.0500    0.0700    0.1000    0.1600    0.2000
-----------------------------------------------------------------------------------
```

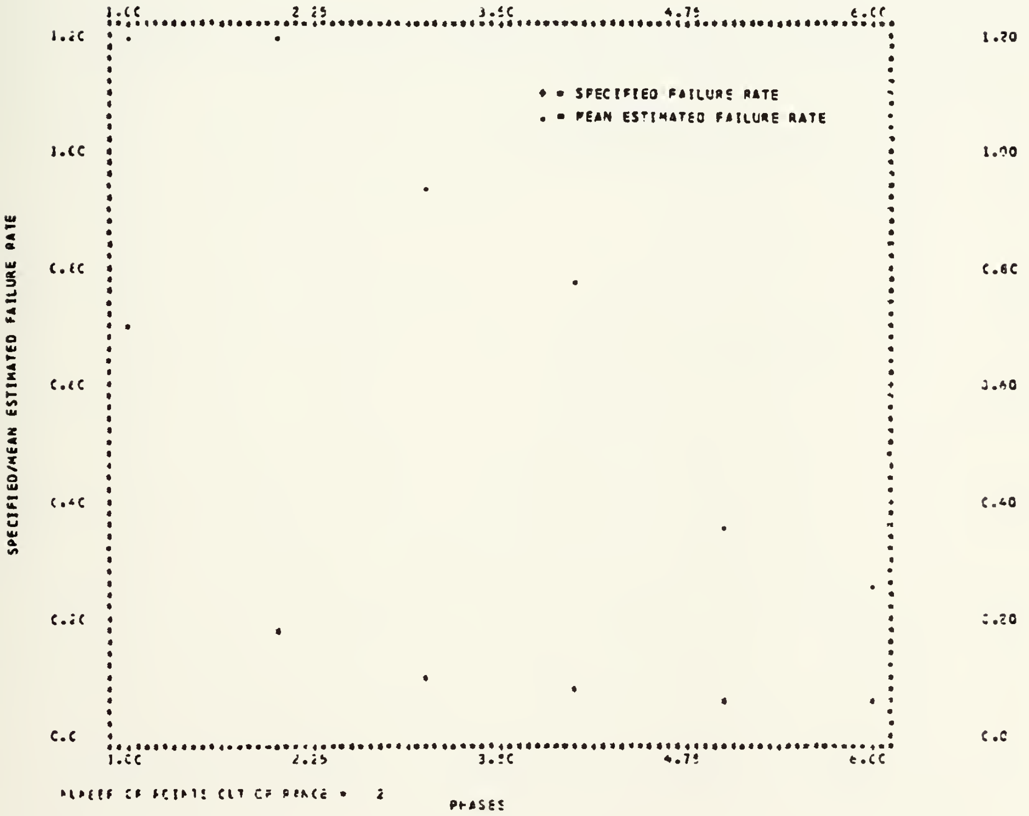


```
                              CASE   7

                              10 ITEMS



PHASE                        1          2          3          4          5          6
----------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000     0.1800     0.1060     0.0760     0.0600     0.0500
PLANNED  TEST  TIME       0.0144     0.0558     0.0548     0.1322     0.1675     0.2010
----------------------------------------------------------------------------------------
MODEL  ESTIMATE           6.0664     1.5263     0.9321     0.7858     0.3577     0.2556
ESTIMATE  ERROR  AS       766.63     749.04     779.30     533.91     456.22     415.28
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      2.0424     1.5045     1.0682     1.7208     0.5474     0.4262
----------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       0.143      0.655      1.642      2.955      4.625      6.625
----------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.0700     0.1700     0.3100     0.3800     0.4600     0.5600
----------------------------------------------------------------------------------------
```

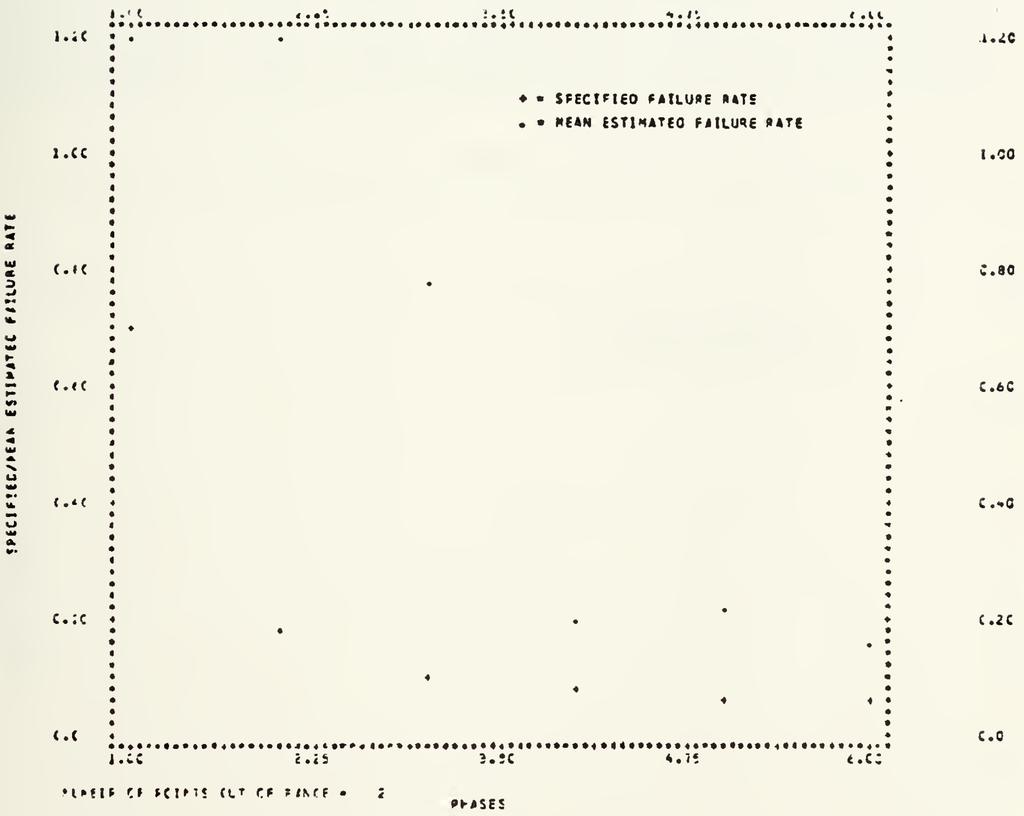


NUMBER OF POINTS OUT OF RANGE = 2

CASE 7

20 ITEMS

```
PHASE                          1         2         3         4         5         6
-------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.1800    0.1060    0.0760    0.0600    0.0500
PLANNED  TEST  TIME       0.0144    0.0258    0.0948    0.1322    0.1675    0.2010
-------------------------------------------------------------------------------------
MODEL  ESTIMATE          12.0566    1.2794    0.7800    0.2056    0.2201    0.1574
ESTIMATE  ERROR  AS      1622.63    610.75    635.87    171.90    266.90    214.89
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     17.3610    3.0669    1.6882    0.1780    0.3673    0.2551
-------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       0.286     1.359     3.282     5.918     9.259    13.227
-------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.1700    0.2200    0.5700    0.7200    0.8300    1.0700
-------------------------------------------------------------------------------------
```



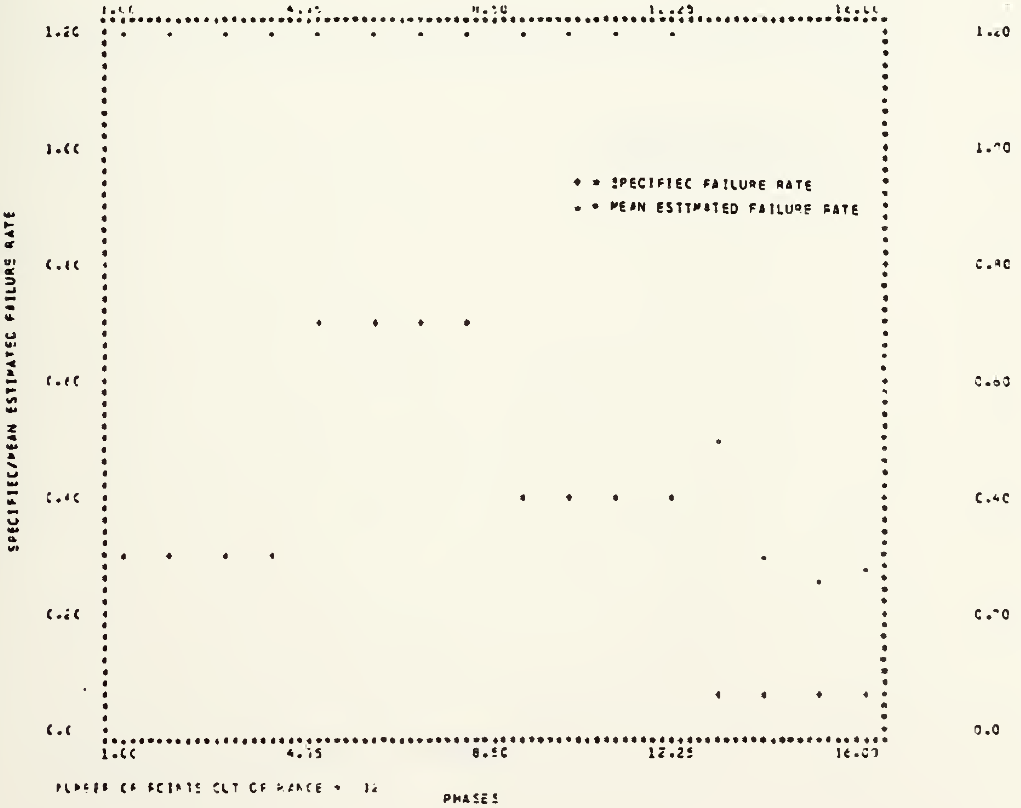
```
                                   CASE  18

                                   5 ITEMS

PHASE                     1         2         3         4         5         6         7         8
----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.3000    0.3000    0.3000    0.3000    0.7000    0.7000    0.7000    0.7000
PLANNED  TEST  TIME     0.0335    0.0335    0.0335    0.0335    0.0144    0.0144    0.0144    0.0144
----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE        15.2334    6.9035   10.1656    4.9846    6.5225    5.4972    3.7474    4.8147
ESTIMATE  ERROR  AS   4977.81   2201.17   3288.53   1561.55    831.78    685.32    435.34    587.81
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION   12.6522    8.9345   10.3442    6.4989   14.3165   12.5801    4.3179    6.4702
----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     0.166     0.333     0.499     0.666     0.737     0.809     0.881     0.952
----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     0.0400    0.0800    0.2000    0.2500    0.2700    0.2900    0.3300    0.4100
----------------------------------------------------------------------------------------------------


**************************************************************************************************************


PHASE                     9        10        11        12        13        14        15        16
----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.4000    0.4000    0.4000    0.4000    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME     0.0251    0.0251    0.0251    0.0251    0.2010    0.2010    0.2010    0.2010
----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         4.5556    3.1953    3.3009    4.1636    0.5057    0.2963    0.2679    0.2716
ESTIMATE  ERROR  AS   1038.90    698.83    725.22    940.91    911.38    492.52    435.79    443.29
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    6.4262    6.2960    4.6361    8.5508    0.3009    0.2219    0.3599    0.6631
----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     1.077     1.202     1.327     1.452     2.455     3.456     4.459     5.459
----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     0.4600    0.4900    0.5800    0.6300    0.6400    0.6700    0.7200    0.7700
----------------------------------------------------------------------------------------------------
```

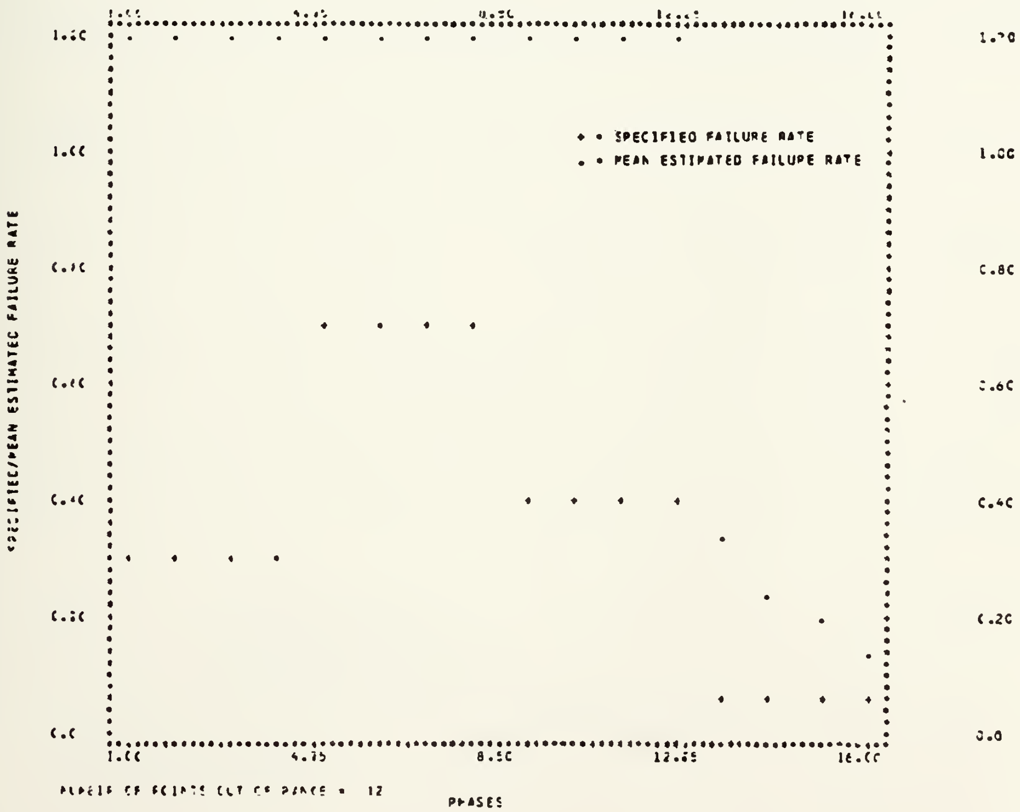


CASE 18

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.0333	0.0333	0.0333	0.0333	0.0144	0.0144	0.0144	0.0144
MODEL ESTIMATE	7.6158	6.3199	4.7355	2.2234	3.5157	2.8503	2.7135	2.4650
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	2435.93	2006.63	1478.51	641.14	455.59	307.18	287.70	252.14
SAMPLE STD DEVIATION	9.4915	9.0550	7.3556	2.0223	6.6443	3.2814	5.0178	2.7750
CUMULATIVE TEST TIME	0.333	0.666	0.999	1.331	1.474	1.617	1.760	1.903
CUMULATIVE FAILURES	0.1200	0.2700	0.3900	0.5300	0.6600	0.7700	0.8100	0.9300

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.0251	0.0251	0.0251	0.0251	0.2010	0.2010	0.2010	0.2010
MODEL ESTIMATE	2.4416	2.3881	2.2531	1.5479	0.3427	0.2422	0.2099	0.1385
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	510.39	497.02	463.32	286.95	585.30	384.39	319.88	176.94
SAMPLE STD DEVIATION	5.5008	5.7201	5.0808	2.5019	0.3608	0.2370	0.2699	0.1447
CUMULATIVE TEST TIME	2.153	2.403	2.653	2.903	4.906	6.903	8.905	10.909
CUMULATIVE FAILURES	1.0200	1.1300	1.2400	1.3300	1.3500	1.4600	1.6300	1.7200



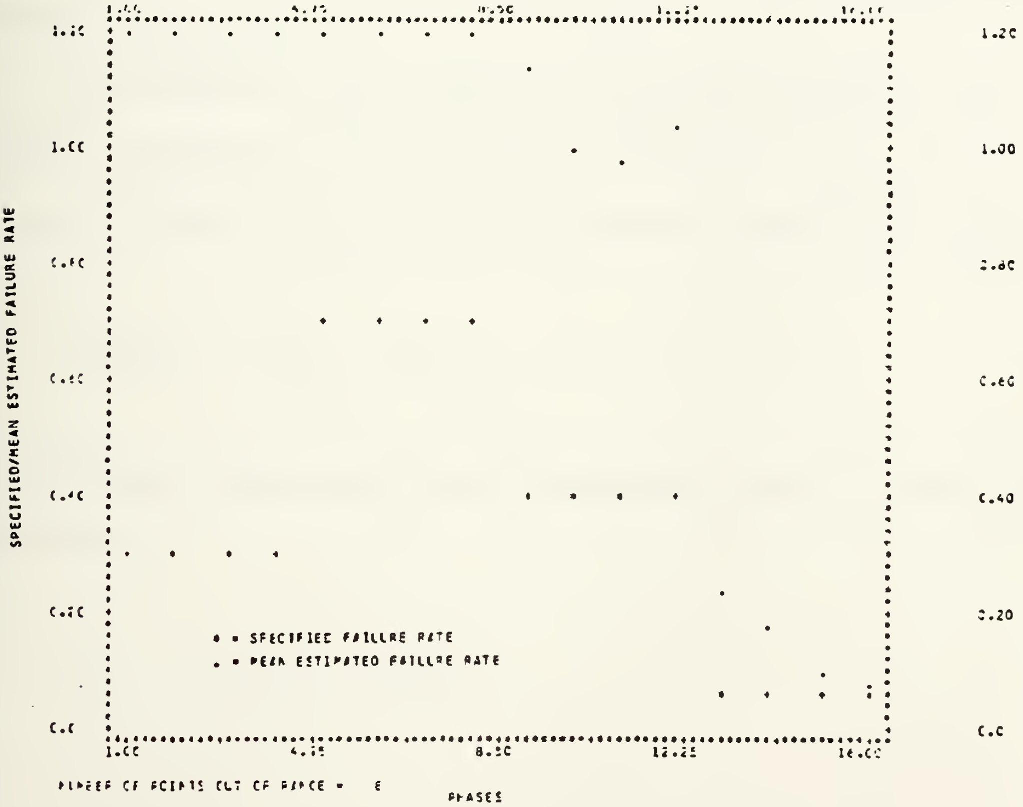
CASE 18

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.0335	0.0335	0.0335	0.0335	0.0144	0.0144	0.0144	0.0144
MODEL ESTIMATE	3.5627	1.9051	1.8587	1.3946	2.5276	2.7251	1.5964	1.7045
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	1087.50	535.02	519.57	364.86	261.09	289.30	128.06	143.51
SAMPLE STD DEVIATION	6.7221	2.1149	2.3548	1.8112	5.3355	7.5045	2.0276	2.5603
CUMULATIVE TEST TIME	0.666	1.334	2.000	2.666	2.952	3.237	3.523	3.809
CUMULATIVE FAILURES	0.1500	0.3900	0.6100	0.8200	1.0200	1.2500	1.4400	1.6200

****

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.0251	0.0251	0.0251	0.0251	0.2010	0.2010	0.2010	0.2010
MODEL ESTIMATE	1.1466	0.9997	0.9717	1.0478	0.2340	0.1723	0.1086	0.0838
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	186.66	149.92	142.94	161.95	368.07	244.59	117.15	67.56
SAMPLE STD DEVIATION	1.3000	0.9304	1.2912	2.2205	0.1603	0.2556	0.0770	0.0911
CUMULATIVE TEST TIME	4.309	4.809	5.309	5.809	9.816	13.812	17.815	21.833
CUMULATIVE FAILURES	1.8000	2.0400	2.2600	2.4000	2.5300	2.7200	2.8600	2.9800



NUMBER OF POINTS OUT OF RANGE = 8

APPENDIX C

Results of Test MOD1

1. Test MOD1

Test MOD1 used the AMSAA model to estimate the failure rate of the items tested except as described below. A more detailed discussion of the modification can be found in Section V-D.

Use of the AMSAA model was modified as follows:

a. The point estimate of the failure rate,

$$r_p = \frac{\text{number of failures during a phase}}{\text{total test time during a phase}} ,$$

was used whenever cumulative test time over all items was less than 10 hours.

b. The slope of the reliability growth pattern was estimated using the current point estimator, r_p, and the previous estimate, $\hat{r}_{i-1}$, of the failure rate as follows:

$$\text{SLOPE} = r_p - \hat{r}_{i-1} .$$

Increasing slope was then determined from the following relationship:

$$r_p - \hat{r}_{i-1} \geq .07 .$$

If the slope was increasing, the point estimate, r_p, was used as the current estimate of the failure rate. Then, the AMSAA model was reinitialized, that is, time and failures prior to an increasing slope were not considered in future estimates made by the model.

2. The Results

Results for Cases 4, 6, 15, and 18 are presented here as representative of the effect the modifications had on the performance of the model. A detailed description of the format of the results can be found in Appendix A.

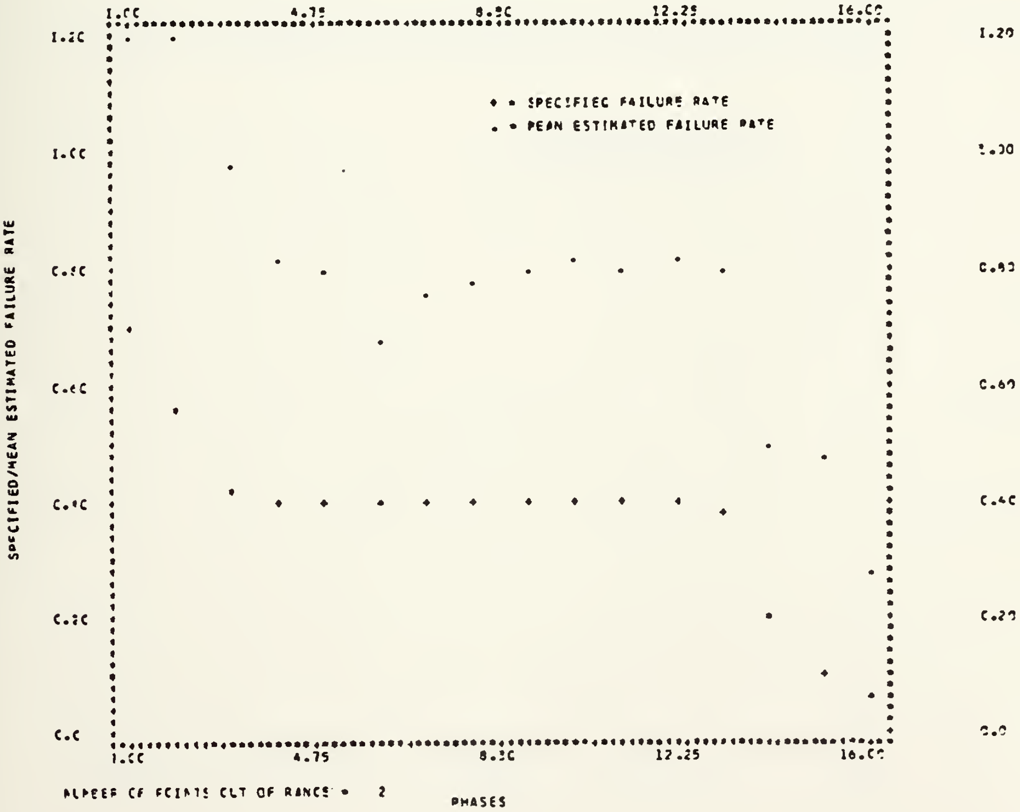
```
                                   CASE   4

                                   5 ITEMS

PHASE                      1         2         3         4         5         6         7         8
--------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.7000    0.5500    0.4250    0.4050    0.4000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME     0.2222    0.2999    0.3824    0.4013    0.4063    0.4063    0.4063    0.4063
--------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         1.3450    1.2900    0.9888    0.8159    0.8067    0.6794    0.7687    0.7757
ESTIMATE  ERROR  AS      92.15    134.54    132.65    101.47    101.68     69.84     92.17     93.93
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.6735    0.7356    0.6517    0.4587    0.4655    0.5281    0.4922    0.5609
--------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     1.074     2.418     4.202     6.049     7.942     9.843    11.697    13.580
--------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     0.6400    1.5100    2.0700    2.8900    3.3200    4.1700    4.9900    5.6900
--------------------------------------------------------------------------------------------------

******************************************************************************************************

PHASE                      9        10        11        12        13        14        15        16
--------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.4000    0.4000    0.4000    0.4000    0.3750    0.2000    0.1000    0.0500
PLANNED  TEST  TIME     0.4063    0.4063    0.4063    0.4063    0.4334 .  0.8126    1.6252    3.2504
--------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.8016    0.8147    0.7922    0.8142    0.7981    0.4975    0.4810    0.2830
ESTIMATE  ERROR  AS     100.41    103.67     98.05    103.55    112.83    148.76    380.97    465.92
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.5095    0.4976    0.4492    0.7469    0.7561    0.4299    1.5370    1.0418
--------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME    15.442    17.319    19.166    21.049    23.079    26.860    34.326    49.304
--------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     6.4400    7.1500    7.7800    8.2700    9.0800   10.0800   10.5600   11.6400
--------------------------------------------------------------------------------------------------
```



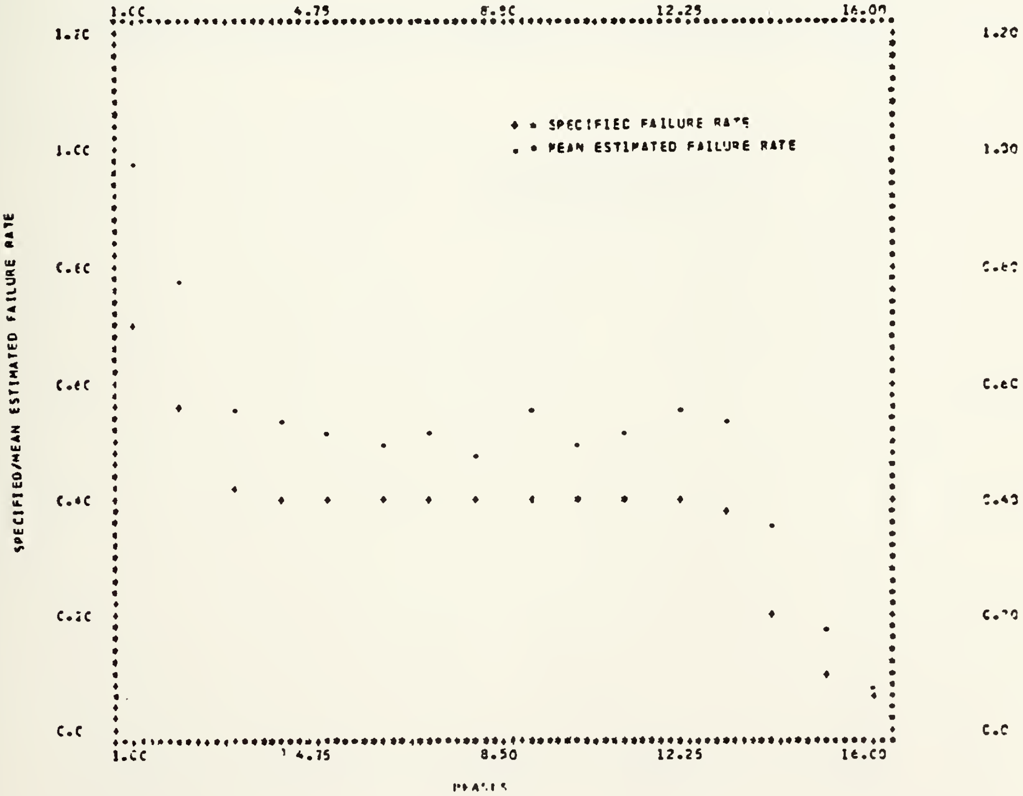
```
                                             CASE   4

                                            10 ITEMS

PHASE                          1          2          3          4          5          6          7          8
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000     0.5500     0.4250     0.4050     0.4000     0.4000     0.4000     0.4000
PLANNED  TEST  TIME       0.2322     0.2955     0.3824     0.4013     0.4063     0.4063     0.4063     0.4063
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.9739     0.7761     0.5674     0.5329     0.5258     0.5026     0.5283     0.4775
ESTIMATE  ERROR  AS        39.13      41.11      33.50      31.58      31.45      25.65      32.08      19.38
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.6085     0.5434     0.3315     0.3378     0.2656     0.3714     0.3459     0.2567
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.136      4.887      8.462     12.133     15.882     19.633     23.410     27.199
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.5400     2.9400     4.1400     5.8000     7.1600     8.4900    10.7000    11.4100
------------------------------------------------------------------------------------------------------------


**************************************************************************************************************


PHASE                          9         10         11         12         13         14         15         16
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000     0.4000     0.4000     0.4000     0.3750     0.2000     0.1000     0.0500
PLANNED  TEST  TIME       0.4063     0.4063     0.4063     0.4063     0.4334     0.8126     1.6252     3.2504
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.5674     0.4926     0.5256     0.5553     0.5457     0.3559     0.1863     0.0858
ESTIMATE  ERROR  AS        41.84      23.15      31.40      38.83      45.53      77.94      86.29      71.59
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.3480     0.3131     0.3157     0.2990     0.3676     0.2904     0.1443     0.0559
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      30.943     34.723     38.459     42.187     46.178     53.627     68.585     98.301
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      12.9700    14.4900    16.0100    17.2200    18.6900    20.5800    22.1900    23.9300
------------------------------------------------------------------------------------------------------------
```



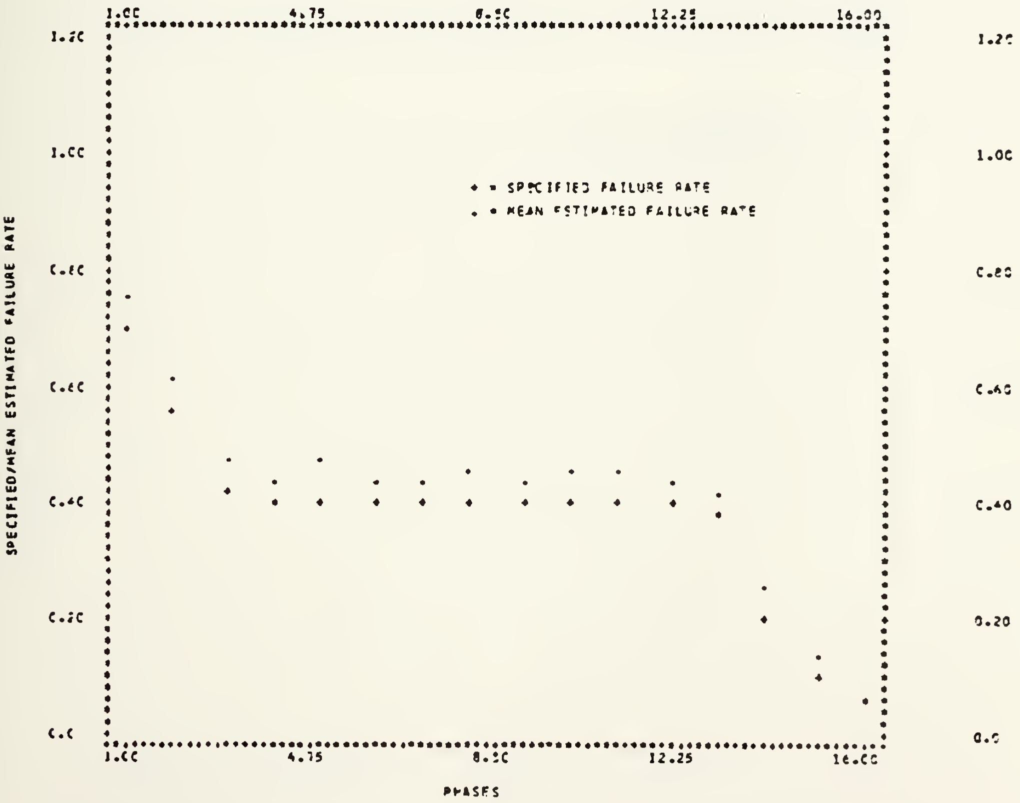
CASE 4

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.5500	0.4250	0.4050	0.4000	0.4000	0.4000	0.4000
PLANNED TEST TIME	0.2222	0.2555	0.3824	0.4013	0.4063	0.4063	0.4063	0.4063
MODEL ESTIMATE	0.7576	0.6155	0.4855	0.4428	0.4775	0.4449	0.4455	0.4675
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	8.23	12.63	14.22	9.33	19.35	11.22	11.38	16.58
SAMPLE STD DEVIATION	0.4180	0.3404	0.2597	0.2565	0.3132	0.2414	0.2085	0.2144
CUMULATIVE TEST TIME	4.313	9.758	16.874	24.303	31.758	39.327	46.759	54.188
CUMULATIVE FAILURES	2.9500	5.8600	8.8100	11.7100	14.7100	17.6100	20.6300	23.5900

* * *

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.3750	0.2000	0.1000	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	0.4334	0.8126	1.6252	3.2504
MODEL ESTIMATE	0.4416	0.4674	0.4527	0.4400	0.4221	0.2574	0.1408	0.0685
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	10.40	16.85	13.17	10.00	12.55	28.71	40.83	36.92
SAMPLE STD DEVIATION	0.2000	0.2363	0.2373	0.2154	0.2216	0.1574	0.0957	0.0787
CUMULATIVE TEST TIME	61.676	69.133	76.672	84.172	92.154	107.154	137.320	197.432
CUMULATIVE FAILURES	27.0400	30.2200	32.8500	36.1700	39.0600	42.0600	44.8000	47.8000



CASE 6

5 ITEMS

```
PHASE                            1        2        3        4        5        6        7        8
-----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000   0.7000   0.7000   0.7000   0.7000   0.4000   0.4000   0.4000
PLANNED  TEST  TIME         0.2322   0.2322   0.2322   0.2322   0.2322   0.4063   0.4063   0.4063
-----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             1.3652   1.4414   1.3780   1.4248   1.3628   1.0920   0.9198   0.7451
ESTIMATE  ERROR  AS          95.03   105.91    96.85   103.54    94.68   172.99   129.94    86.27
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.6434   0.8539   0.7429   0.7812   0.6953   0.7198   0.6374   0.5086
-----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         1.061    2.128    3.209    4.305    5.374    7.210    9.075   10.968
-----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.7400   1.4900   2.2000   2.6400   3.4700   4.3300   4.9700   5.8900
-----------------------------------------------------------------------------------------------------
```

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PHASE                            9       10       11       12       13       14       15       16
-----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.4000   0.4000   0.1000   0.1000   0.1000   0.1000   0.1000   0.1000
PLANNED  TEST  TIME         0.4063   0.4063   1.6252   1.6252   1.6252   1.6252   1.6252   1.6252
-----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.7355   0.7320   0.3303   0.2486   0.2230   0.2152   0.2373   0.2224
ESTIMATE  ERROR  AS          83.89    83.01   230.34   148.63   123.04   115.18   137.33   122.42
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.5162   0.5231   0.4434   0.2996   0.2061   0.1708   0.3124   0.1600
-----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        12.856   14.742   22.241   29.722   37.201   44.676   52.044   59.523
-----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         6.6000   6.9200   7.7400   8.7300   9.6300  10.1900  10.8900  11.9000
-----------------------------------------------------------------------------------------------------
```

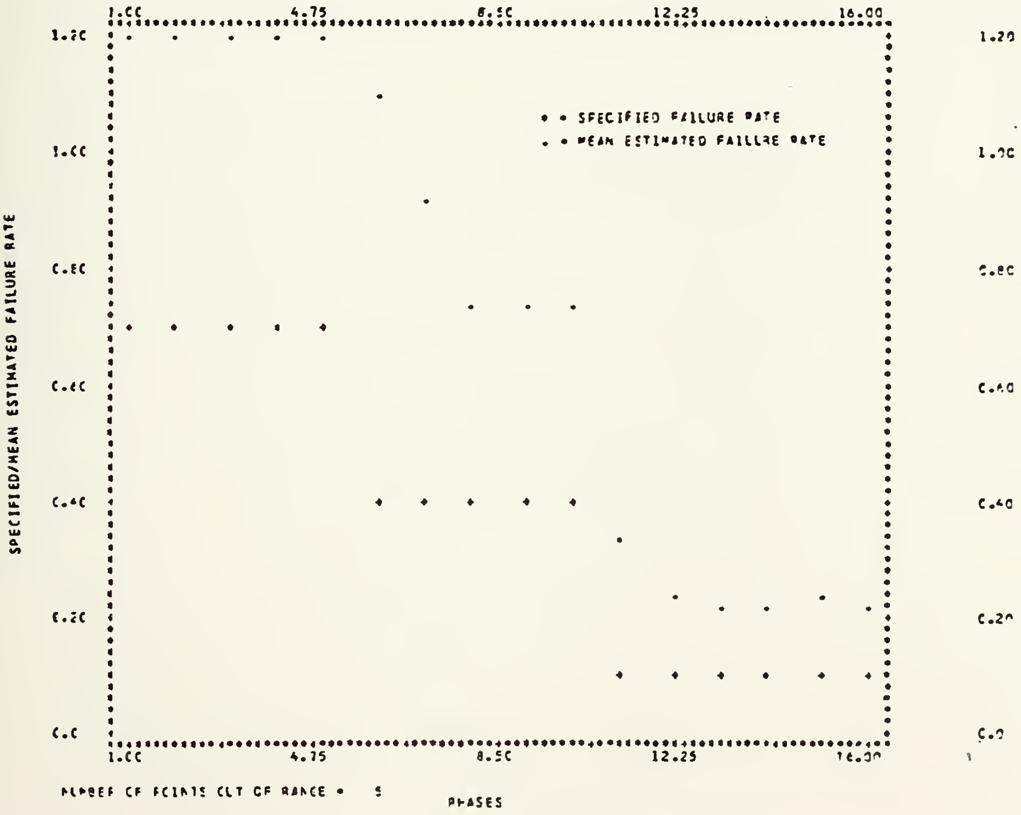

```
                                   CASE   6

                                   10 ITEMS

PHASE                         1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME      0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.9192    0.9590    0.8404    0.9337    0.8496    0.5467    0.5256    0.4668
ESTIMATE  ERROR  AS       31.32     37.00     20.05     33.38     21.37     36.67     31.41     16.69
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.5075    0.5922    0.4066    0.4841    0.5002    0.4415    0.4015    0.2793
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      2.158     4.277     6.441     8.553    10.729    14.459    18.287    22.093
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      1.3900    3.0100    4.3100    5.9200    7.0600    8.6600    9.9800   11.1700
------------------------------------------------------------------------------------------------------

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PHASE                         9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME      0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.5489    0.5073    0.2168    0.1753    0.1549    0.2546    0.1553    0.1678
ESTIMATE  ERROR  AS       37.22     26.82    116.84     75.27     54.94    154.56     55.32     67.82
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.3280    0.3046    0.2033    0.1891    0.1187    1.0256    0.0939    0.1495
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     25.831    29.565    44.552    59.418    74.438    89.320   104.331   119.306
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     12.7500   14.0300   15.3900   17.4500   19.0200   20.5800   22.1800   23.2600
------------------------------------------------------------------------------------------------------
```
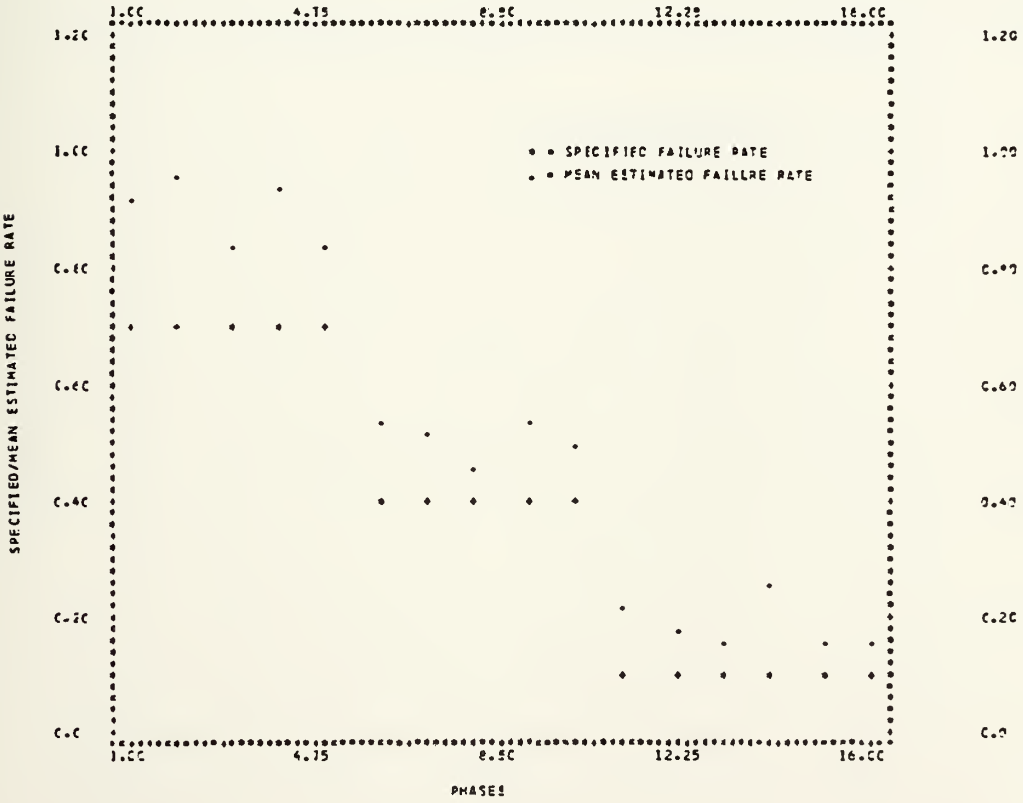



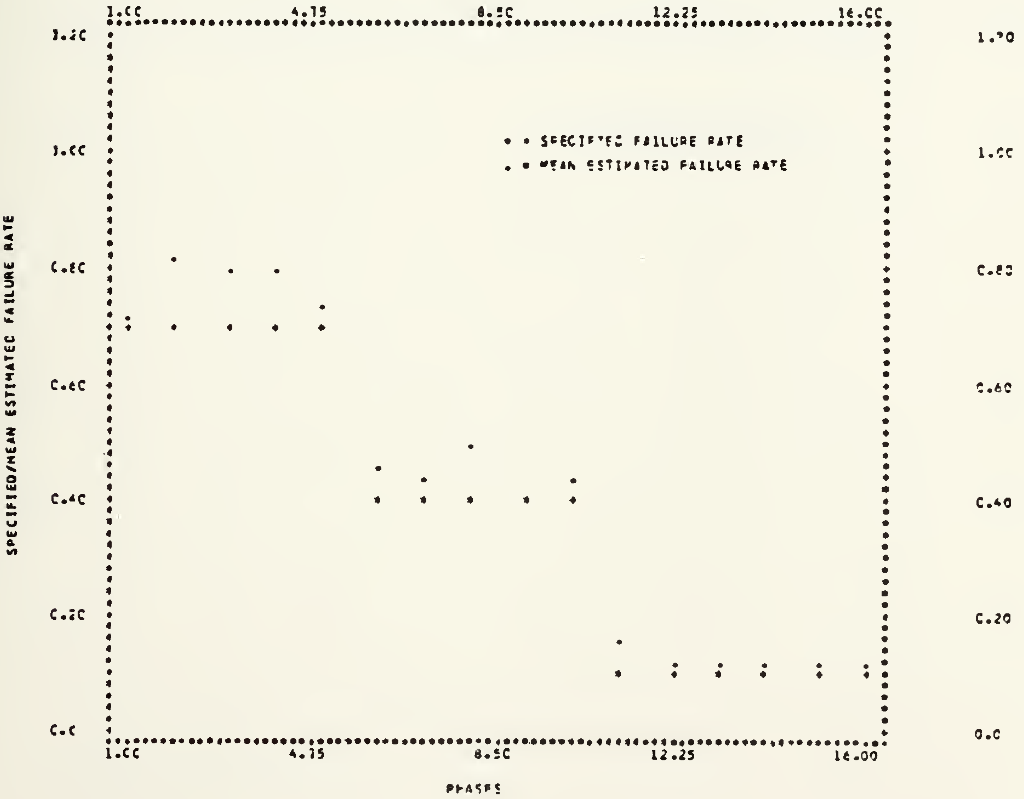
CASE 6

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.7000	0.7000	0.4000	0.4000	0.4000
PLANNED TEST TIME	0.2322	0.2322	0.2322	0.2322	0.2322	0.4063	0.4063	0.4063
MODEL ESTIMATE	0.7251	0.8111	0.7970	0.7949	0.7358	0.4506	0.4485	0.4528
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	3.58	15.86	13.86	13.56	5.11	12.64	12.24	13.21
SAMPLE STD DEVIATION	0.4087	0.4101	0.3854	0.3754	0.4263	0.2427	0.1866	0.2416
CUMULATIVE TEST TIME	4.294	8.561	12.842	17.130	21.415	28.505	36.410	43.831
CUMULATIVE FAILURES	2.7700	6.0500	9.2000	12.3000	15.2100	18.0700	21.0200	24.3000

* * *

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.4063	0.4063	1.6252	1.6252	1.6252	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.4087	0.4423	0.1678	0.1266	0.1151	0.1188	0.1273	0.1224
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	2.17	10.58	67.83	26.62	15.06	18.76	27.28	22.40
SAMPLE STD DEVIATION	0.2044	0.2269	0.1802	0.0588	0.0479	0.0775	0.0554	0.0608
CUMULATIVE TEST TIME	51.373	58.856	88.818	118.487	148.455	178.515	208.545	238.637
CUMULATIVE FAILURES	27.0300	30.0600	33.1700	36.4600	39.4300	41.5700	45.2600	48.2700



```
                                   CASE  15

                                   5 ITEMS

PHASE                                  1         2         3         4         5         6         7         8
----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE               0.7000    0.3000    0.0500    0.5000    0.2000    0.1000    0.4000    0.3000
PLANNED  TEST  TIME               0.2322    0.5417    3.2504    0.3250    0.8126    1.6252    0.4063    0.5417
----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE                   1.5230    0.9539    0.1409    0.6078    0.5407    0.2337    0.5952    0.6176
ESTIMATE  ERROR  AS               117.57    217.97    181.70     21.55    170.34    233.72     49.79    105.86
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION              1.0093    0.8239    0.2124    0.5533    0.4577    0.3385    0.4937    0.4566
----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME               1.074     3.573    18.481    19.990    23.722    31.225    33.112    35.575
----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES               0.7500    1.5200    2.1600    2.9500    3.5300    4.3700    4.9600    5.8400
----------------------------------------------------------------------------------------------------------------

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PHASE                                  9        10        11        12        13        14        15        16
----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE               0.2000    0.1500    0.3000    0.3000    0.2000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME               0.8126    1.0835    0.5417    0.5417    0.8126    1.6252    1.6252    1.6252
----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE                   2.4787    0.3198    0.4945    0.6131    0.5051    0.3279    0.3391    0.1680
ESTIMATE  ERROR  AS              1139.34    113.20     64.82    104.37    152.53    227.88    239.14     68.07
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION             19.8275    0.2624    0.3734    0.3696    0.3243    0.5730    1.3141    0.1567
----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME              39.351    44.288    46.786    49.254    53.009    60.464    68.097    75.729
----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES               6.3500    7.3600    8.3100    8.7000    9.5700   10.2900   11.0700   11.7200
----------------------------------------------------------------------------------------------------------------
```

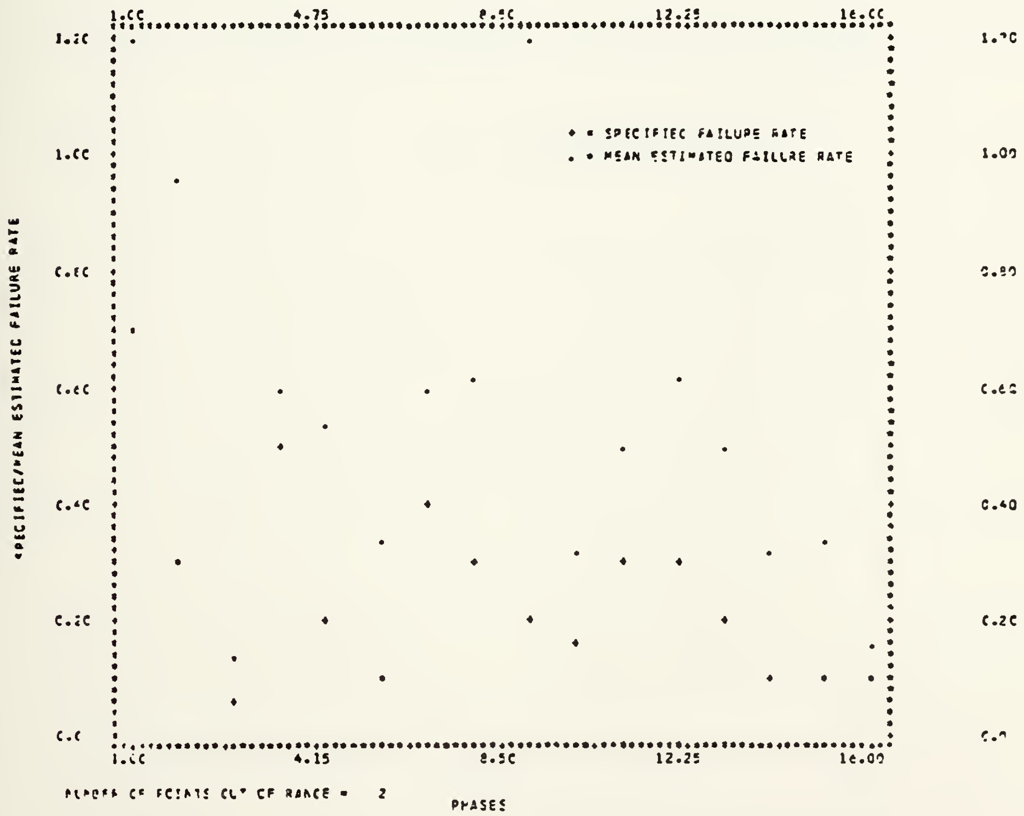

NUMBER OF POINTS OUT OF RANGE =   2

CASE 15

10 ITEMS

```
PHASE                          1         2         3         4         5         6         7         8
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.3000    0.0500    0.5000    0.2000    0.1000    0.4000    0.3000
PLANNED  TEST  TIME       0.2322    0.5417    3.2504    0.3250    0.8126    1.6252    0.4063    0.5417
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.0392    0.5081    0.0731    0.5402    0.3202    0.2040    0.5040    0.4673
ESTIMATE  ERROR  AS        48.46     69.36     46.26      8.05     60.09    103.99     25.99     55.77
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.5388    0.3629    0.0726    0.4624    0.2796    0.2326    0.3755    0.2766
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.104     7.083    37.101    40.105    47.606    62.576    66.304    71.262
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.7700    3.3500    4.8500    6.3000    7.8200    9.2700   10.9800   12.4700
-----------------------------------------------------------------------------------------------------------


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PHASE                          9        10        11        12        13        14        15        16
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.2000    0.1500    0.3000    0.3000    0.2000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME       0.8126    1.0835    0.5417    0.5417    0.8126    1.6252    1.6252    1.6252
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.3503    0.2534    0.3880    0.3811    0.2694    0.1653    0.1496    0.1492
ESTIMATE  ERROR  AS        75.16     68.94     29.34     27.04     34.71     65.35     49.62     49.22
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.3430    0.2358    0.2636    0.2299    0.1952    0.1192    0.1032    0.1029
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      78.788    88.725    93.707    98.702   106.248   121.305   136.297   151.192
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      13.6900   15.5700   16.8500   18.6800   19.9200   21.4100   23.2900   24.8700
-----------------------------------------------------------------------------------------------------------
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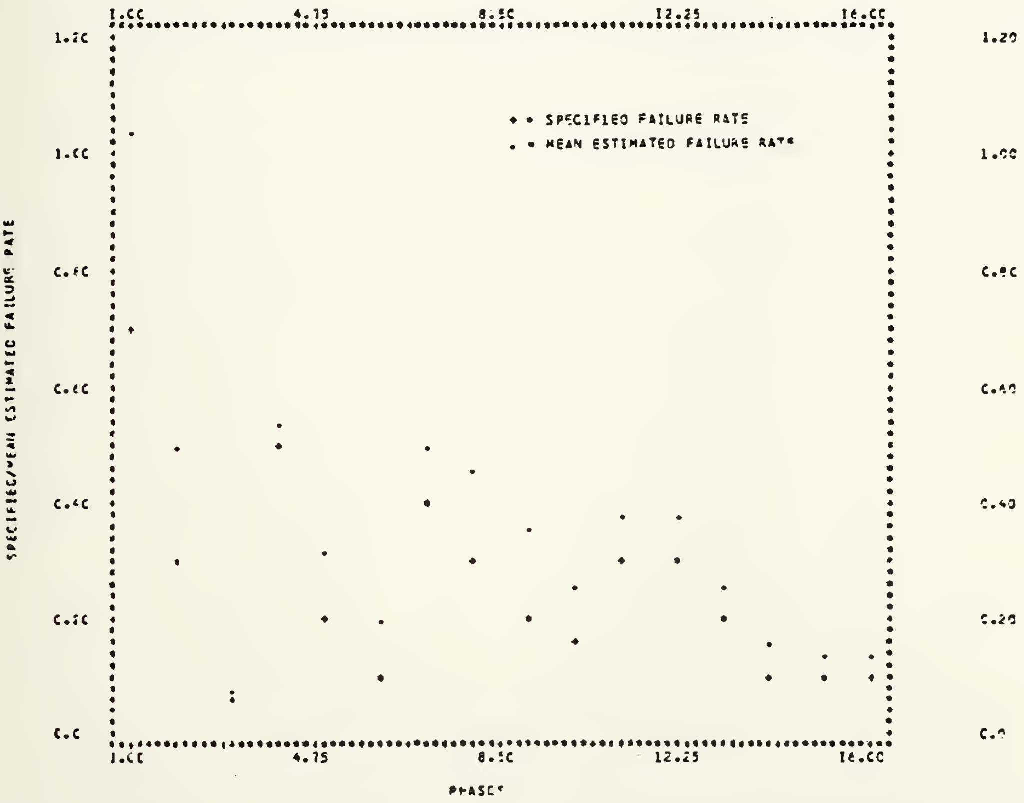
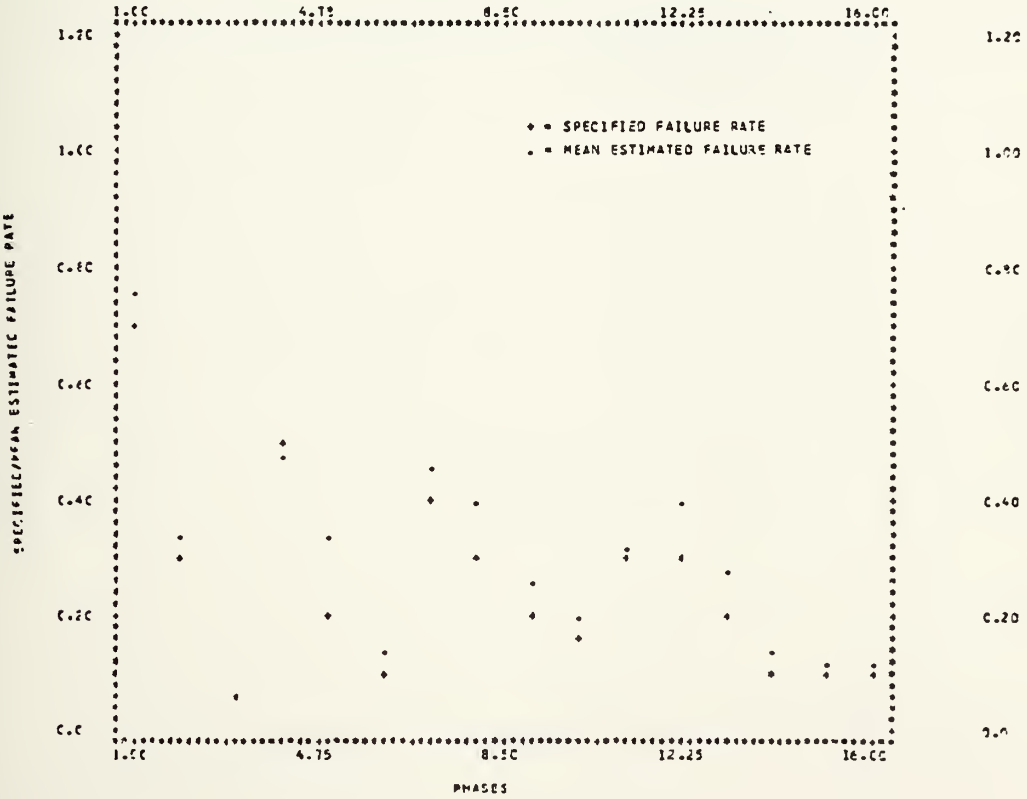


CASE 15

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.3000	0.0500	0.5000	0.2000	0.1000	0.4000	0.3000
PLANNED TEST TIME	0.2322	0.5417	3.2504	0.3250	0.8126	1.6252	0.4063	0.5417
MODEL ESTIMATE	0.7622	0.3412	0.0621	0.4766	0.3480	0.1383	0.4535	0.3518
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	8.89	13.75	24.25	4.68	73.98	38.35	13.37	30.59
SAMPLE STD DEVIATION	0.4205	0.1842	0.0376	0.3083	0.3174	0.0665	0.2624	0.3677
CUMULATIVE TEST TIME	4.272	14.288	34.066	60.098	92.034	124.511	132.346	142.278
CUMULATIVE FAILURES	2.9500	5.8500	9.0000	11.7600	14.7300	18.0500	21.3200	24.4900

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.2000	0.1500	0.3000	0.3000	0.2000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.8126	1.0835	0.5417	0.5417	0.8126	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.2565	0.1941	0.3250	0.3924	0.2753	0.1346	0.1146	0.1242
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	28.23	29.40	8.34	30.80	37.66	34.59	14.58	24.24
SAMPLE STD DEVIATION	0.1618	0.1076	0.1696	0.2558	0.1836	0.0793	0.0509	0.1080
CUMULATIVE TEST TIME	157.243	177.242	187.247	197.196	212.194	242.173	272.258	302.306
CUMULATIVE FAILURES	27.4000	30.4300	33.4100	36.6600	39.6100	42.6600	45.4900	48.4300



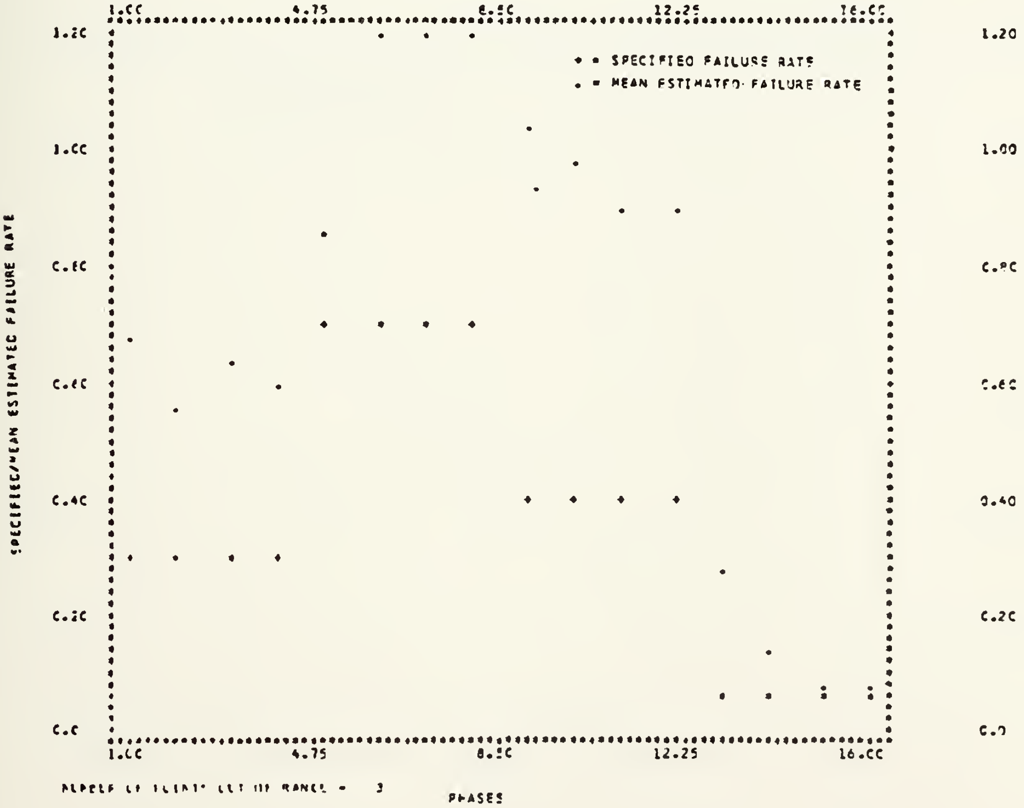
CASE 18

5 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.5417	0.5417	0.5417	0.5417	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	0.6856	0.5667	0.6498	0.5917	0.8700	1.2716	1.4143	1.4726
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	128.55	88.90	116.60	97.23	24.28	81.66	102.04	110.37
SAMPLE STD DEVIATION	0.3824	0.3011	0.3908	0.4396	0.7138	0.8571	0.8568	0.8539
CUMULATIVE TEST TIME	2.509	5.042	7.507	10.020	11.119	12.158	13.223	14.288
CUMULATIVE FAILURES	0.7100	1.4200	2.2100	2.7800	3.3600	4.2700	4.8100	5.9700

****

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	1.0469	0.9890	0.8992	0.9081	0.2748	0.1447	0.0834	0.0715
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	161.72	147.24	124.81	127.02	449.59	189.42	66.77	43.08
SAMPLE STD DEVIATION	0.7404	0.6987	0.5733	0.6434	0.3971	0.2837	0.1450	0.0665
CUMULATIVE TEST TIME	16.166	18.057	19.941	21.804	36.765	51.970	67.164	82.335
CUMULATIVE FAILURES	6.3900	7.4900	7.6900	8.6900	9.7800	10.4800	11.0600	11.9100



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                                   CASE  18

                                   10 ITEMS

PHASE                        1         2         3         4         5         6         7         8
----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.3000    0.3000    0.3000    0.3000    0.7000    0.7000    0.7000    0.7000
PLANNED  TEST  TIME     0.5417    0.5417    0.5417    0.5417    0.2322    0.2322    0.2322    0.2322
----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.4091    0.3629    0.4506    0.4797    0.7845    0.8801    0.8770    0.9473
ESTIMATE  ERROR  AS      36.36     20.97     50.21     59.89     12.08     25.72     25.29     35.33
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.2150    0.2511    0.2874    0.2759    0.4821    0.6365    0.5282    0.5064
----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     4.927     9.532    14.858    19.747    21.909    24.061    26.213    28.341
----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     1.5900    3.0400    4.7300    6.3600    7.9400    9.0600   10.5100   12.4700
----------------------------------------------------------------------------------------------------

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PHASE                        9        10        11        12        13        14        15        16
----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.4000    0.4000    0.4000    0.4000    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME     0.4063    0.4063    0.4063    0.4063    3.2504    3.2504    3.2504    3.2504
----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.6137    0.4838    0.4971    0.5100    0.1312    0.0745    0.0607    0.0595
ESTIMATE  ERROR  AS      53.42     20.94     24.28     27.50    162.43     48.56     21.40     19.03
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.4341    0.3364    0.3328    0.3241    0.1779    0.1076    0.0698    0.0457
----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME    32.125    35.990    39.705    43.459    73.610   103.736   133.795   163.986
----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES    13.6700   15.0600   16.4200   17.6700   19.1700   20.8400   22.0400   23.8200
----------------------------------------------------------------------------------------------------
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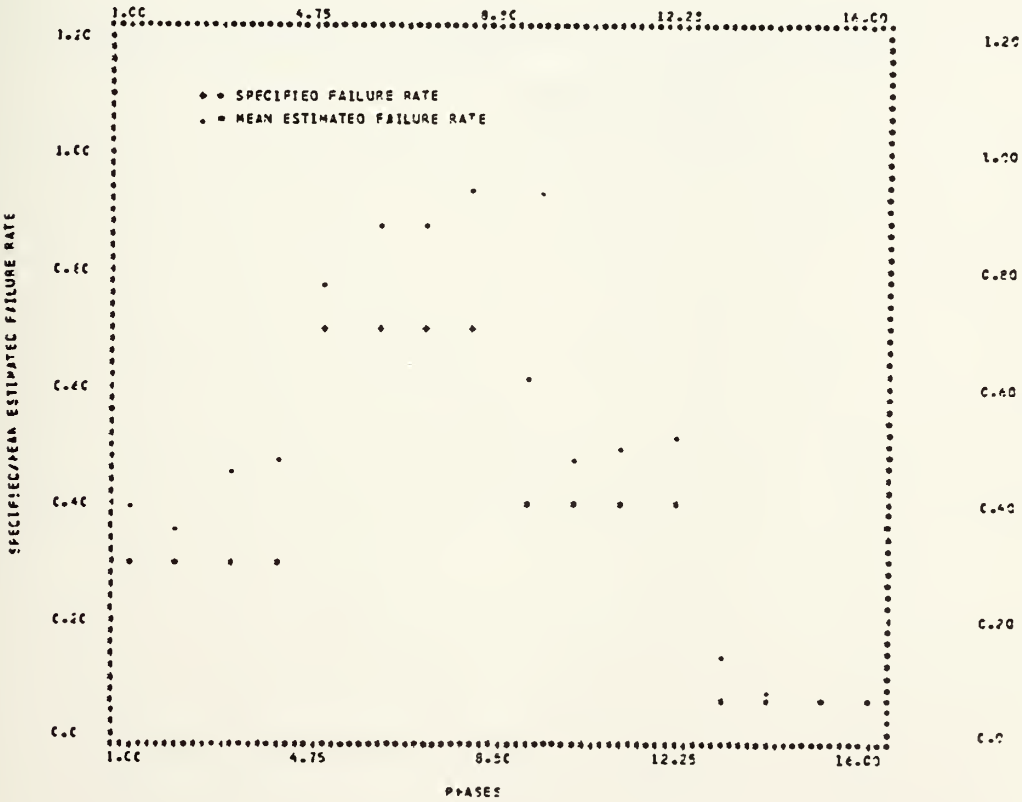


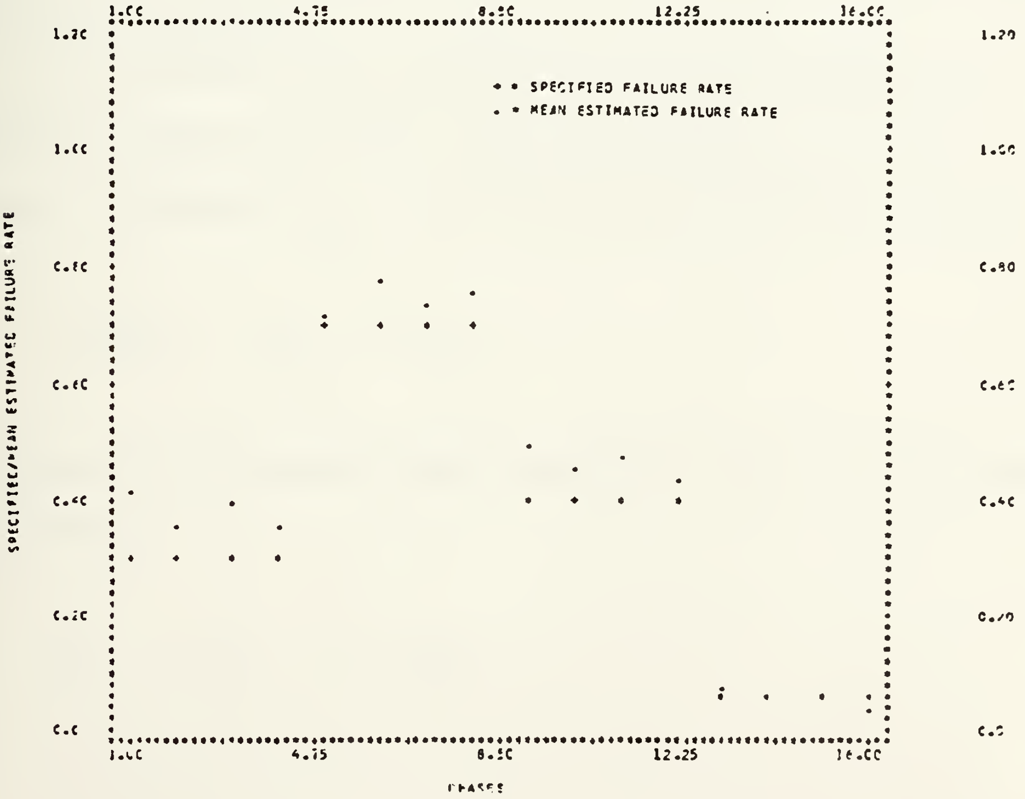
CASE 18

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.5417	0.5417	0.5417	0.5417	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	0.4185	0.3518	0.4095	0.3681	0.7206	0.7865	0.7496	0.7502
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	39.49	17.25	36.50	22.70	2.94	12.36	7.08	7.17
SAMPLE STD DEVIATION	0.2905	0.1970	0.2986	0.1911	0.3467	0.4426	0.4265	0.3909
CUMULATIVE TEST TIME	9.996	19.986	29.890	39.908	44.206	48.472	52.744	57.039
CUMULATIVE FAILURES	3.0300	5.9900	9.1800	12.0600	14.8100	17.9900	21.0300	23.9900

……

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.5097	0.4649	0.4842	0.4427	0.0837	0.0521	0.0524	0.0482
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	27.42	16.24	21.05	10.66	67.20	4.19	4.85	3.66
SAMPLE STD DEVIATION	0.3713	0.2430	0.2403	0.2282	0.0963	0.0321	0.0289	0.0219
CUMULATIVE TEST TIME	64.569	72.091	79.547	87.097	147.563	208.236	267.736	327.823
CUMULATIVE FAILURES	26.9100	29.8600	33.1100	36.0300	38.5000	41.5400	44.6200	47.5000



APPENDIX D

Results of Test MOD2

1. Test MOD2

Test MOD2 used the AMSAA model to estimate the failure rate of the items tested except as described below. A more detailed discussion of the modification can be found in Section V-D.

Use of the AMSAA model was modified as follows:

a. The point estimate of the failure rate,

$$r_p = \frac{\text{number of failures during a phase}}{\text{total test time during a phase}} ,$$

was used whenever cumulative test time over all items was less than 10 hours.

b. The slope of the reliability growth pattern was estimated using the current point estimate, r_p, and the previous estimate, $\hat{r}_{i-1}$, of the failure rate as follows:

$$\text{SLOPE} = r_p - \hat{r}_{i-1} .$$

Increasing slope was then determined from the following relationship:

$$r_p - \hat{r}_{i-1} \geq 2\hat{r}_{i-1} ,$$

If the slope was increasing, the point estimate, r_p, was used as the current estimate of the failure rate. Then, the AMSAA model was reinitialized, that is, time and failures prior to an increasing slope were not considered in future estimates made by the model.

2. The Results

Results for Cases 4, 6, 15, and 18 are presented here as representative of the effect the modifications had on the performance of the model. A detailed description of the format of the results can be found in Appendix A.

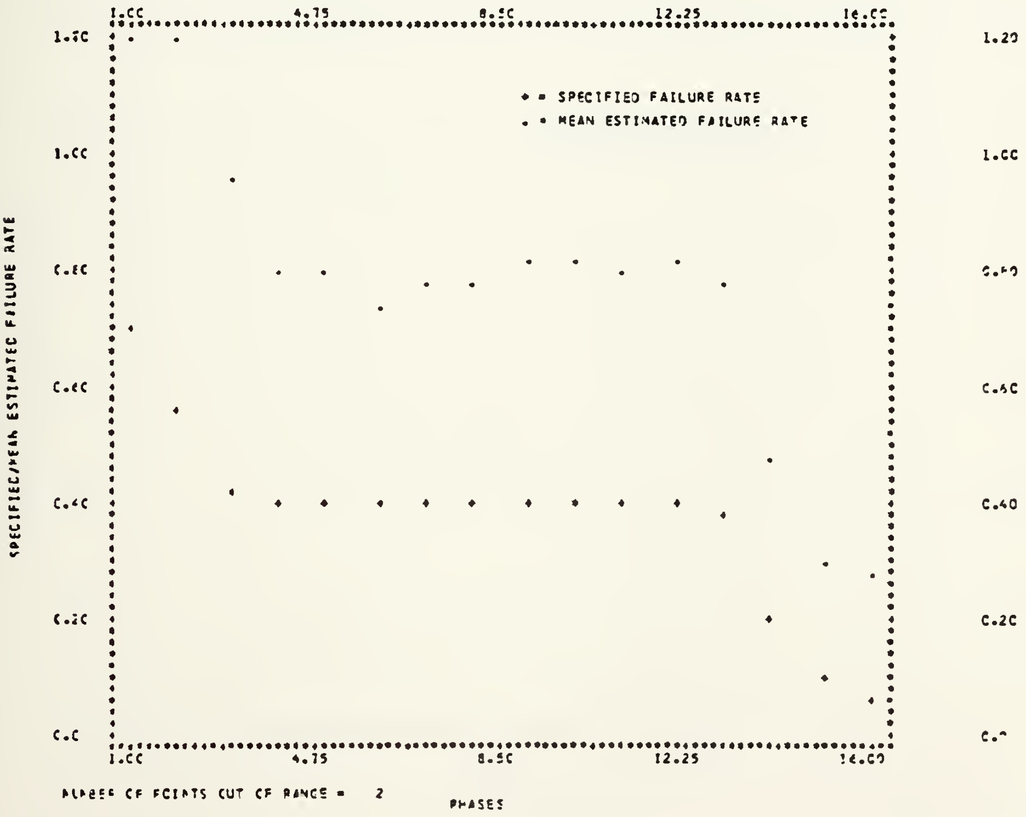
CASE 4

5 ITEMS

```
PHASE                          1        2        3        4        5        6        7        8
------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000   0.5500   0.4250   0.4050   0.4000   0.4000   0.4000   0.4000
PLANNED  TEST  TIME       0.2222   0.2555   0.3824   0.4013   0.4063   0.4063   0.4063   0.4063
------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.3264   1.3166   0.9675   0.8075   0.8067   0.7462   0.7787   0.7841
ESTIMATE  ERROR  AS        89.49   139.74   127.64    99.37   101.68    86.56    94.68    96.03
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.6978   0.7415   0.6545   0.4593   0.4655   0.4834   0.4941   0.5520
------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.074    2.418    4.202    6.049    7.942    9.843   11.697   13.580
------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.6400   1.4300   2.0500   2.8900   3.5500   4.1500   4.9000   5.7700
------------------------------------------------------------------------------------------------
```

```
**********************************************************************************************************

PHASE                          9       10       11       12       13       14       15       16
------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000   0.4000   0.4000   0.4000   0.3750   0.2000   0.1000   0.0500
PLANNED  TEST  TIME       0.4063   0.4063   0.4063   0.4063   0.4334   0.8126   1.6252   3.2504
------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.8182   0.8239   0.7928   0.8124   0.7898   0.4846   0.2906   0.2821
ESTIMATE  ERROR  AS       104.55   105.98    98.21   103.11   110.62   142.28   190.57   464.13
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.4992   0.4621   0.4572   0.7451   0.7571   0.4203   0.3418   1.0460
------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      15.442   17.319   19.186   21.049   23.079   26.860   34.326   49.304
------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       6.4400   7.1100   7.7800   8.3600   9.1700  10.0800  10.4900  11.5800
------------------------------------------------------------------------------------------------
```



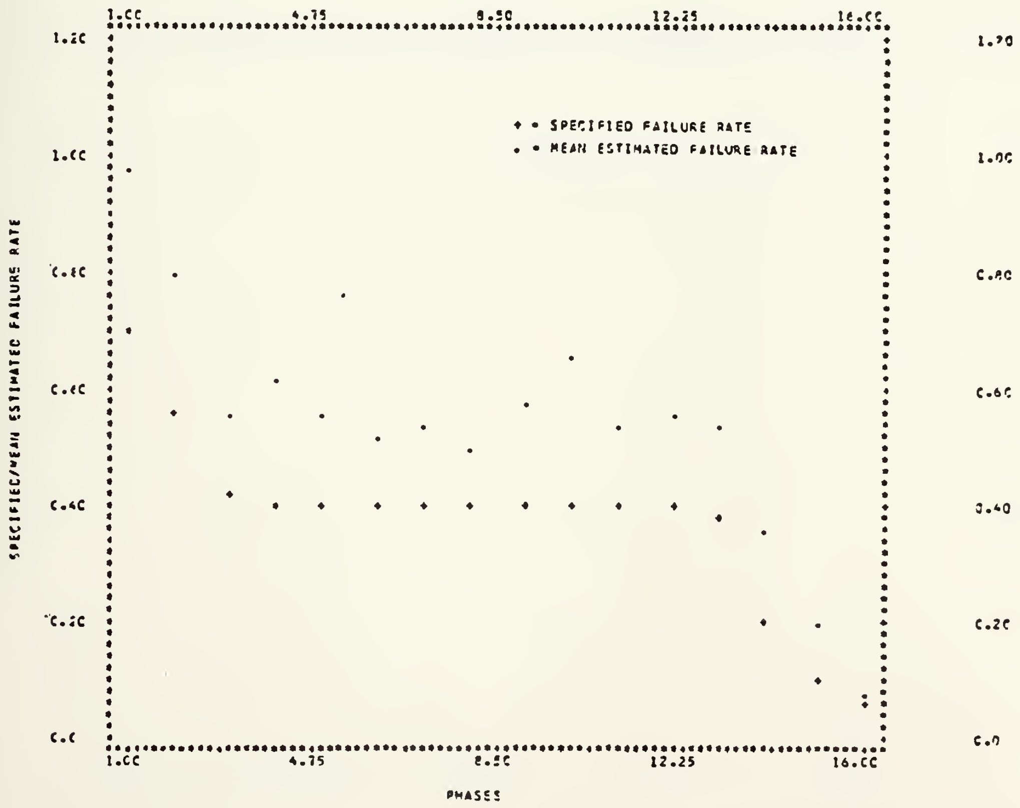
```
                                        CASE   4

                                        10 ITEMS

PHASE                          1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.5500    0.4250    0.4050    0.4000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2322    0.2555    0.3824    0.4013    0.4063    0.4063    0.4063    0.4063
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.9739    0.7946    0.5631    0.6275    0.5517    0.5162    0.5330    0.4930
ESTIMATE  ERROR  AS        39.13     44.48     32.50     54.94     37.93     29.06     33.24     23.25
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.6085    0.5476    0.3305    0.6033    0.2743    0.2771    0.3637    0.3044
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.136     4.887     9.462    12.133    15.883    19.623    23.410    27.195
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.5400    2.8500    4.1100    5.7400    7.1600    8.4100   10.1000   11.4100
------------------------------------------------------------------------------------------------------

**********************************************************************************************************

PHASE                          9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.4000    0.4000    0.3750    0.2000    0.1000    0.0500
PLANNED  TEST  TIME       0.4063    0.4063    0.4063    0.4063    0.4334    0.8126    1.6252    3.2504
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.5740    0.6525    0.5374    0.5670    0.5484    0.3801    0.1560    0.0884
ESTIMATE  ERROR  AS        43.51     63.11     34.35     41.75     46.23     80.04     55.98     76.71
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.3474    1.6556    0.3229    0.3362    0.3533    0.2651    0.1523    0.0582
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      30.943    34.723    38.459    42.187    46.178    53.627    68.565    98.301
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      12.9700   14.4500   16.0100   17.2200   18.8200   20.5800   22.1900   23.5300
------------------------------------------------------------------------------------------------------
```



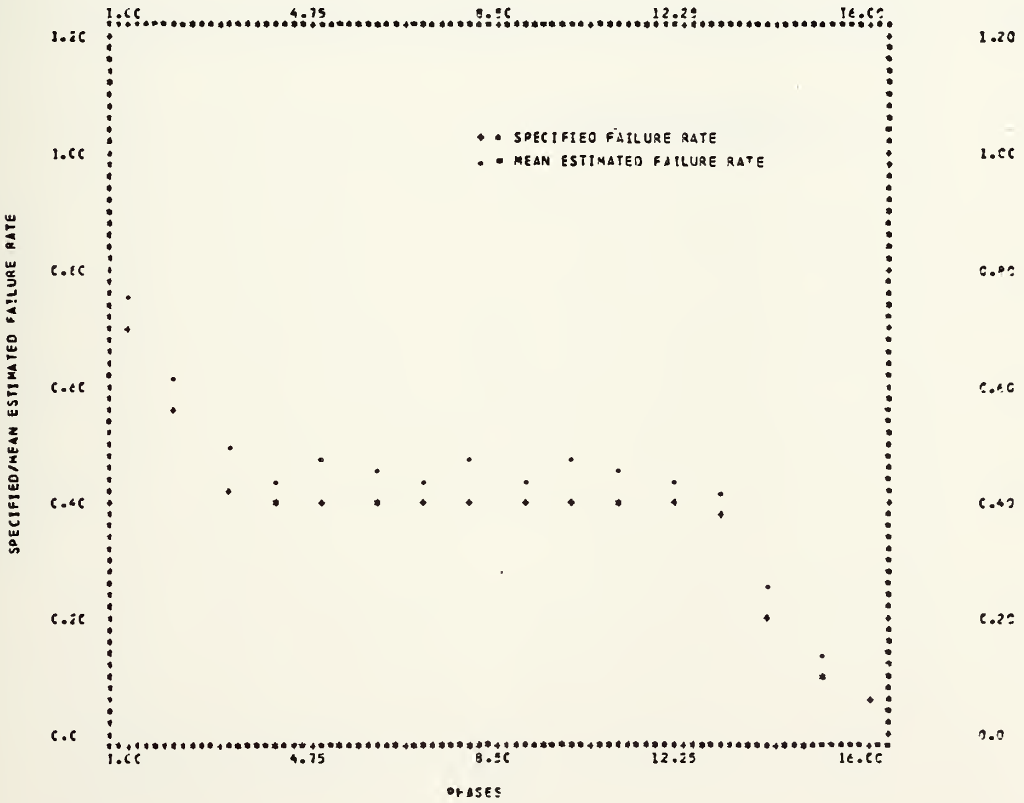
```
                                         CASE   4

                                         20 ITEMS

PHASE                          1         2         3         4         5         6         7         8
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.5500    0.4250    0.4050    0.4000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2322    0.2955    0.3824    0.4013    0.4063    0.4063    0.4063    0.4063
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.7576    0.6134    0.5010    0.4458    0.4792    0.4507    0.4446    0.4703
ESTIMATE  ERROR  AS         8.23     11.53     17.88     10.07     19.81     12.67     11.15     17.58
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.4180    0.3452    0.2728    0.2616    0.3128    0.2457    0.2144    0.2141
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       4.313     9.758    16.874    24.303    31.798    39.327    46.759    54.188
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       2.9500    5.8600    8.8700   11.7100   14.7100   17.6100   20.8300   23.5500
---------------------------------------------------------------------------------------------------------


************************************************************************************************************


PHASE                          9        10        11        12        13        14        15        16
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.4000    0.4000    0.3750    0.2000    0.1000    0.0500
PLANNED  TEST  TIME       0.4063    0.4063    0.4063    0.4063    0.4334    0.8126    1.6252    3.2504
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.4444    0.4709    0.4536    0.4404    0.4203    0.2571    0.1403    0.0696
ESTIMATE  ERROR  AS        11.11     17.72     13.40     10.10     12.07     28.53     40.30     39.22
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.2009    0.2357    0.2362    0.2134    0.2216    0.1556    0.0943    0.0302
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      61.676    69.122    76.672    84.172    92.154   107.154   137.320   197.437
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      27.0400   30.2200   32.8500   36.1700   39.0600   42.0600   44.8000   47.8000
---------------------------------------------------------------------------------------------------------
```



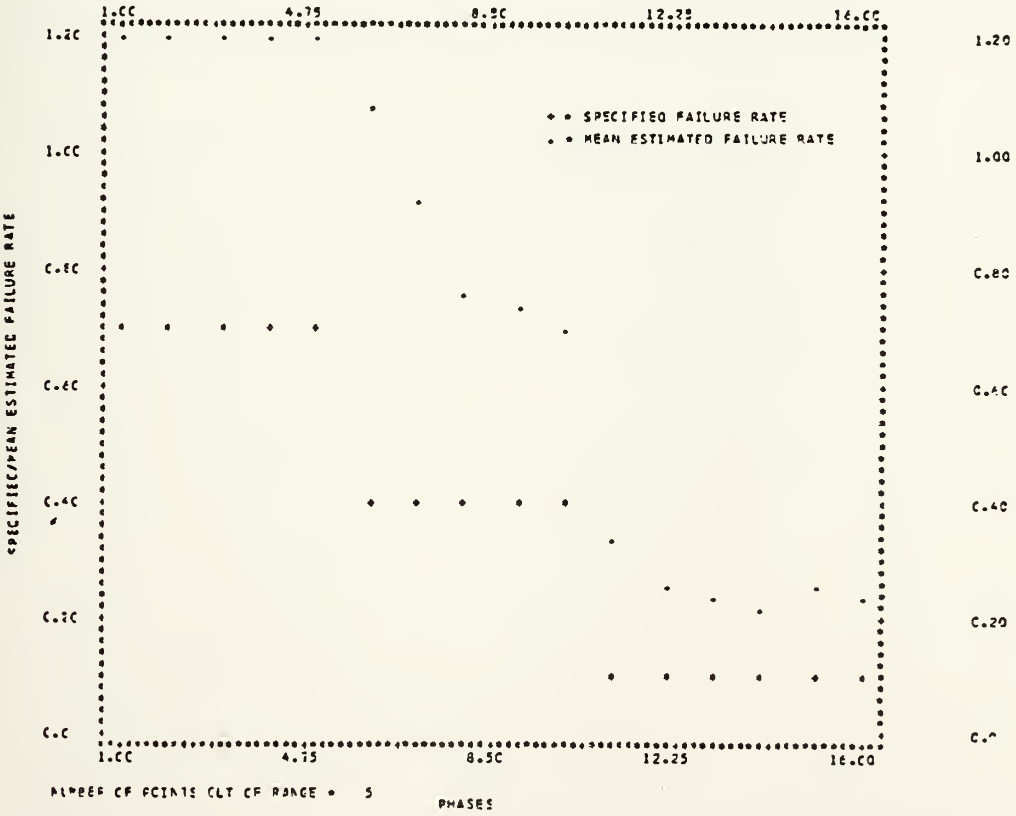
```
                                    CASE   6

                                    5 ITEMS

PHASE                          1         2         3         4         5         6         7         8
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.3652    1.4585    1.3739    1.4043    1.3421    1.0711    0.9157    0.7604
ESTIMATE  ERROR  AS        95.03    108.36     96.28    100.61     91.72    167.77    128.93     90.10
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.6434    0.8648    0.7531    0.7801    0.6943    0.7167    0.6386    0.4895
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.061     2.128     3.209     4.305     5.374     7.210     9.075    10.968
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.7400    1.4100    2.1100    2.8400    3.4700    4.4200    4.9600    5.6500
--------------------------------------------------------------------------------------------------------


**********************************************************************************************************

PHASE                          9        10        11        12        13        14        15        16
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME       0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.7354    0.7096    0.3340    0.2607    0.2375    0.2262    0.2507    0.2365
ESTIMATE  ERROR  AS        83.85     77.39    233.99    160.72    137.47    126.17    150.67    136.50
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.5135    0.5292    0.4373    0.2927    0.2092    0.1717    0.3109    0.1637
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      12.856    14.742    22.241    29.722    37.201    44.676    52.044    59.523
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       6.6000    7.0200    7.8200    8.8300    9.6300   10.1500   10.8500   11.5100
--------------------------------------------------------------------------------------------------------
```



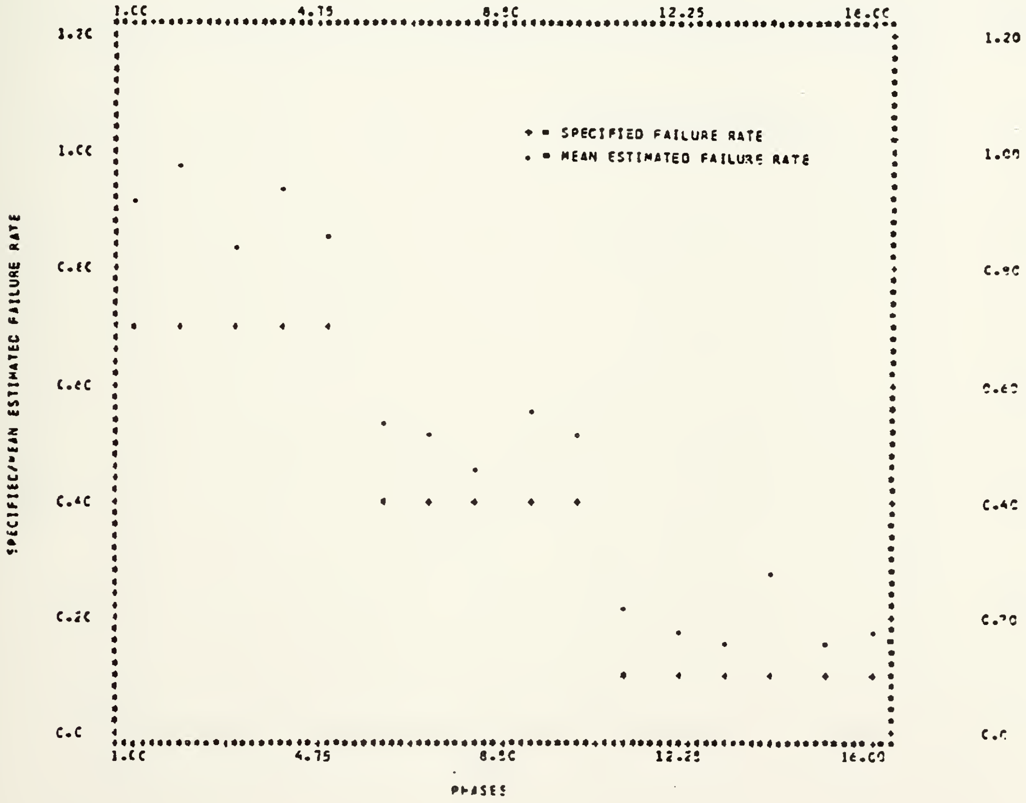
```
                                        CASE   6

                                        10 ITEMS

PHASE                          1         2         3         4         5         6         7         8
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.9152    0.9703    0.8404    0.9337    0.8568    0.5468    0.5277    0.4544
ESTIMATE  ERROR  AS        31.22     38.62     20.05     33.38     22.40     36.71     31.53     12.59
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.5079    0.5532    0.4066    0.4841    0.4544    0.4441    0.4024    0.2753
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.158     4.277     6.441     8.553    10.725    14.499    18.287    22.097
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.3500    2.9500    4.3100    5.9200    7.0600    8.6600    9.9800   11.1700
-----------------------------------------------------------------------------------------------------------

*************************************************************************************************************

PHASE                          9        10        11        12        13        14        15        16
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME       0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.5524    0.5131    0.2114    0.1731    0.1586    0.2852    0.1665    0.1746
ESTIMATE  ERROR  AS        38.10     28.27    111.36     73.07     58.60    185.23     66.48     74.65
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.3345    0.2949    0.2019    0.1854    0.1254    1.0424    0.1050    0.1505
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      25.831    29.565    44.552    59.418    74.438    89.320   104.331   119.306
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      12.7500   13.9400   15.3500   17.4500   19.0200   20.4700   22.1800   22.7700
-----------------------------------------------------------------------------------------------------------
```

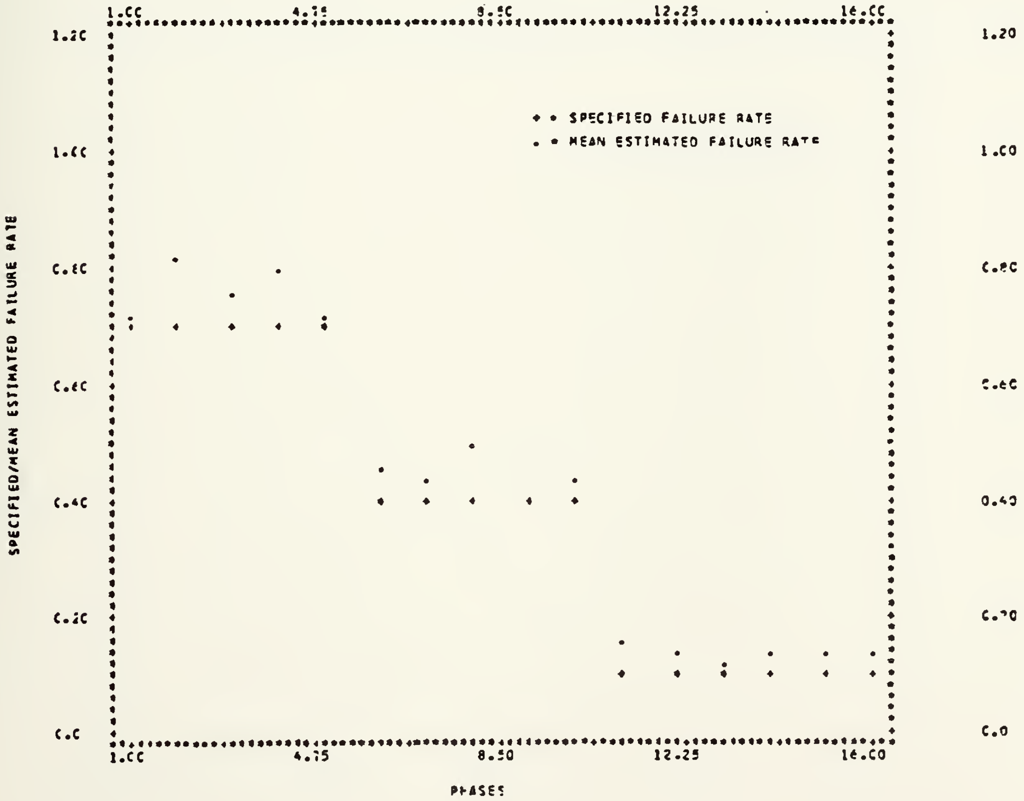


CASE 6

20 ITEMS

```
PHASE                            1         2         3         4         5         6         7         8
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME         0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.7251    0.8171    0.7619    0.7920    0.7287    0.4545    0.4458    0.4541
ESTIMATE  ERROR  AS           3.58     16.72      8.84     13.14      4.10     13.64     11.46     13.53
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.4087    0.4078    0.4044    0.3825    0.4318    0.2423    0.1882    0.2411
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         4.294     8.561    12.842    17.130    21.419    28.905    36.410    43.831
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         2.7700    6.0000    9.2000   12.3000   15.2100   18.0700   21.0200   24.3000
---------------------------------------------------------------------------------------------------------
```

```
PHASE                            9        10        11        12        13        14        15        16
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME         0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.4030    0.4359    0.1645    0.1306    0.1220    0.1385    0.1382    0.1309
ESTIMATE  ERROR  AS           0.74      8.98     64.48     30.57     21.98     38.52     38.15     30.87
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.2055    0.2249    0.1760    0.0585    0.0487    0.1138    0.1131    0.0685
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        51.373    58.856    88.818   118.487   148.459   178.519   208.549   238.637
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        27.0300   30.0600   33.1700   36.4600   39.4300   41.9700   45.2600   48.2200
---------------------------------------------------------------------------------------------------------
```

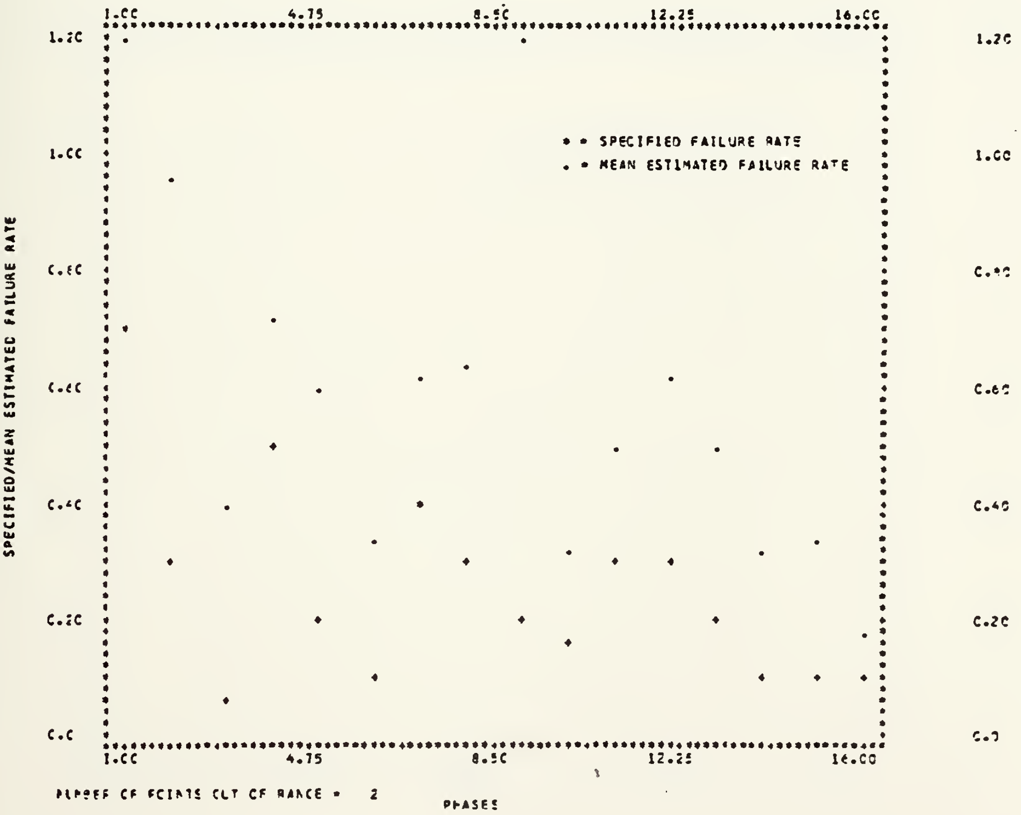


CASE 15

5 STEPS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.3000	0.0500	0.5000	0.2000	0.1000	0.4000	0.3000
PLANNED TEST TIME	0.2222	0.5417	3.2504	0.3250	0.8126	1.6252	0.4063	0.5417
MODEL ESTIMATE	1.5230	0.9698	0.4058	0.7188	0.5982	0.3474	0.6154	0.6382
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	117.57	223.26	711.51	43.77	199.10	247.40	53.84	112.73
SAMPLE STD DEVIATION	1.0093	0.8302	0.8308	0.6278	0.5043	0.3731	0.5081	0.4729
CUMULATIVE TEST TIME	1.074	3.573	18.481	19.990	23.722	31.225	33.112	35.575
CUMULATIVE FAILURES	0.7500	1.4800	2.1600	2.9300	3.5100	4.3200	4.9600	5.7600

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.2000	0.1500	0.3000	0.3000	0.2000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.8126	1.0835	0.5417	0.5417	0.8126	1.6252	1.6252	1.6252
MODEL ESTIMATE	2.5016	0.3201	0.4980	0.6164	0.4992	0.3215	0.3405	0.1783
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	1150.80	113.39	66.01	105.46	149.59	221.54	240.53	78.34
SAMPLE STD DEVIATION	19.8357	0.2558	0.3740	0.3707	0.3226	0.5710	1.3138	0.1617
CUMULATIVE TEST TIME	39.351	44.288	46.786	49.254	53.005	60.484	68.097	79.729
CUMULATIVE FAILURES	6.3500	7.3600	8.3100	8.7000	9.5700	10.3600	11.0700	11.7200



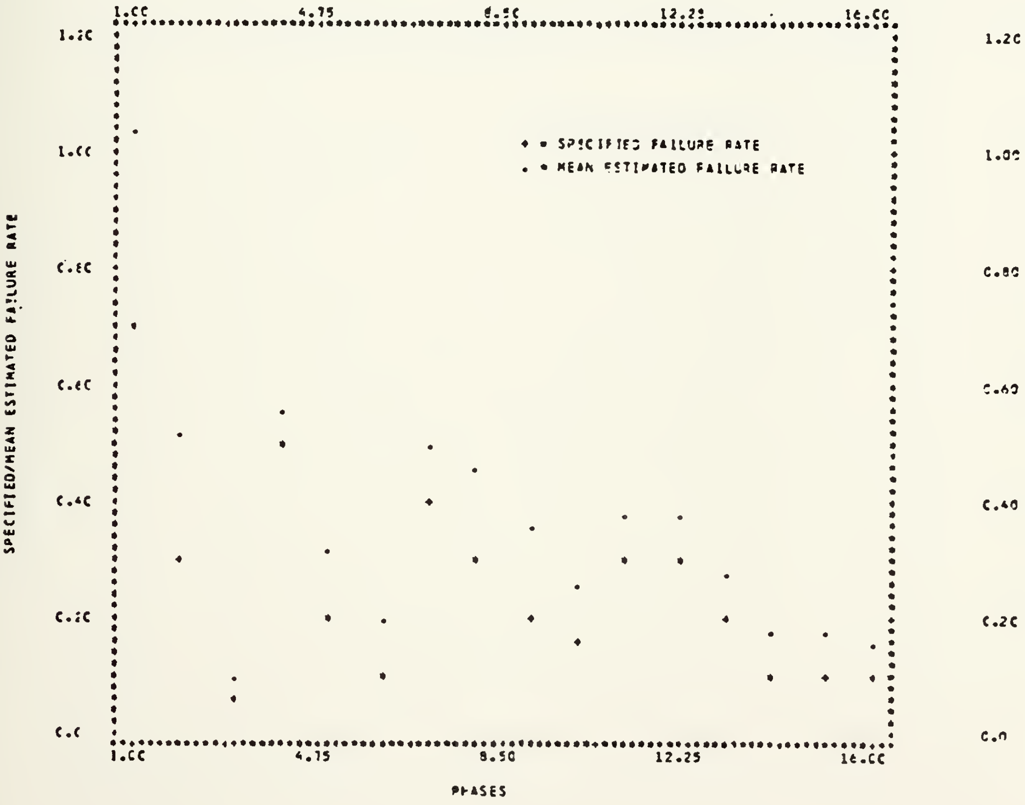
```
                                          CASE  15

                                          10 ITEMS

PHASE                      1          2          3          4          5          6          7          8
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.7000     0.3000     0.0500     0.5000     0.2000     0.1000     0.4000     0.3000
PLANNED  TEST  TIME     0.2322     0.5417     3.2504     0.3250     0.8126     1.6252     0.4063     0.5417
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         1.0392     0.5182     0.0987     0.5584     0.3268     0.1532     0.4922     0.4603
ESTIMATE  ERROR  AS      48.46      72.74      97.43      11.69      63.41      53.24      23.04      53.43
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.5388     0.3643     0.1555     0.4639     0.2906     0.1759     0.3322     0.2654
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     2.104      7.063     37.101     40.105     47.606     62.376     66.304     71.262
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     1.7700     3.2400     4.8500     6.3000     7.8200     9.2700    10.5800    12.4700
---------------------------------------------------------------------------------------------------------


*************************************************************************************************************


PHASE                      9         10         11         12         13         14         15         16
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.2000     0.1500     0.3000     0.3000     0.2000     0.1000     0.1000     0.1000
PLANNED  TEST  TIME     0.8126     1.0835     0.5417     0.5417     0.8126     1.6252     1.6252     1.6252
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.3500     0.2513     0.3859     0.3844     0.2769     0.1708     0.1700     0.1675
ESTIMATE  ERROR  AS      75.00      67.51      28.64      28.13      38.43      70.84      70.01      67.54
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.3357     0.2339     0.2644     0.2298     0.2123     0.1212     0.1789     0.1242
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME    78.788     88.725     93.707     98.702    106.248    121.305    136.257    151.192
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES    13.6900    15.5700    16.8300    18.6800    19.5200    21.4100    23.2900    24.3600
---------------------------------------------------------------------------------------------------------
```



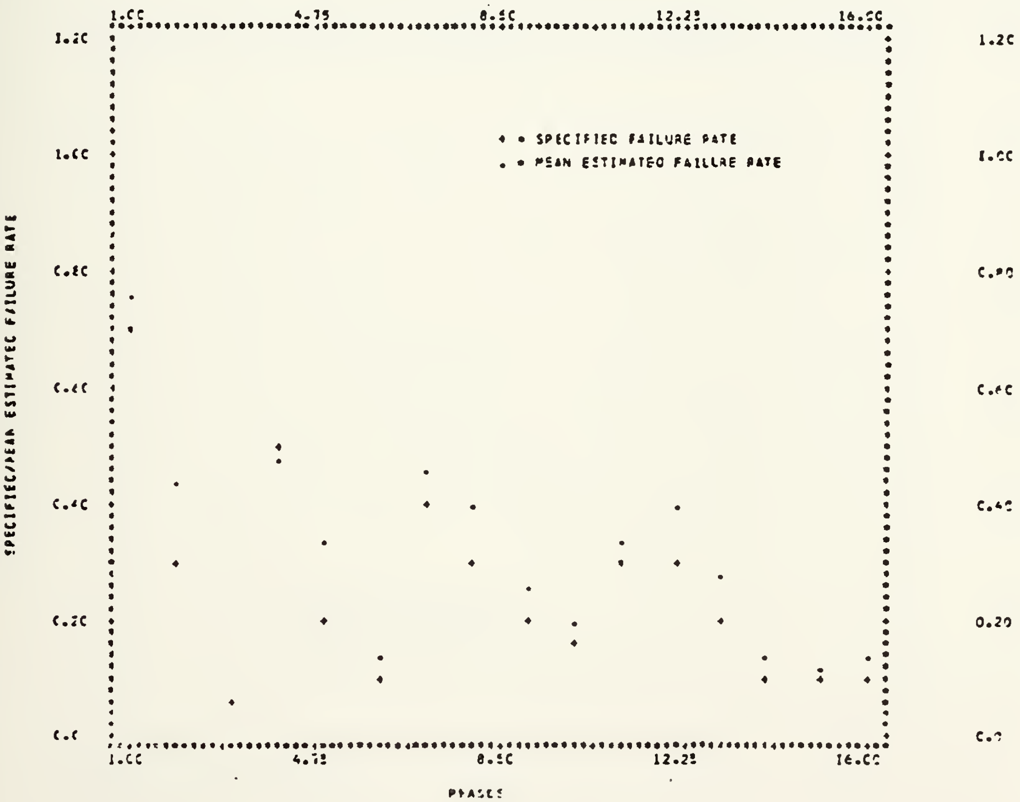
```
                                      CASE  15

                                      20 ITEMS

PHASE                          1         2         3         4         5         6         7         8
----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.3000    0.0500    0.5000    0.2000    0.1000    0.4000    0.3000
PLANNED  TEST  TIME       0.2222    0.5417    3.2504    0.3250    0.8126    1.6252    0.4063    0.5417
----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.7622    0.4393    0.0615    0.4776    0.3369    0.1364    0.4543    0.3622
ESTIMATE  ERROR  AS         8.89     46.43     22.92      4.48     68.45     36.44     13.58     20.72
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.4265    0.3188    0.0390    0.3073    0.3103    0.0668    0.2614    0.2672
----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       4.272    14.288    74.066    80.098    95.034   124.911   132.346   142.278
----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       2.9500    5.8100    9.0000   11.7600   14.7300   18.0500   21.3200   24.4500
----------------------------------------------------------------------------------------------------------

*************************************************************************************************************

PHASE                          9        10        11        12        13        14        15        16
----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.2000    0.1500    0.3000    0.3000    0.2000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME       0.8126    1.0835    0.5417    0.5417    0.8126    1.6252    1.6252    1.6252
----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.2579    0.1985    0.3390    0.3983    0.2812    0.1403    0.1222    0.1376
ESTIMATE  ERROR  AS        28.95     32.33     12.99     32.77     40.60     40.34     22.18     37.62
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.1616    0.1060    0.1568    0.2533    0.1828    0.0844    0.0535    0.1243
----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     157.243   177.242   187.247   197.196   212.194   242.173   272.298   302.306
----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      27.4000   30.4300   33.4100   36.6600   39.6100   42.6600   45.4500   47.5700
----------------------------------------------------------------------------------------------------------
```

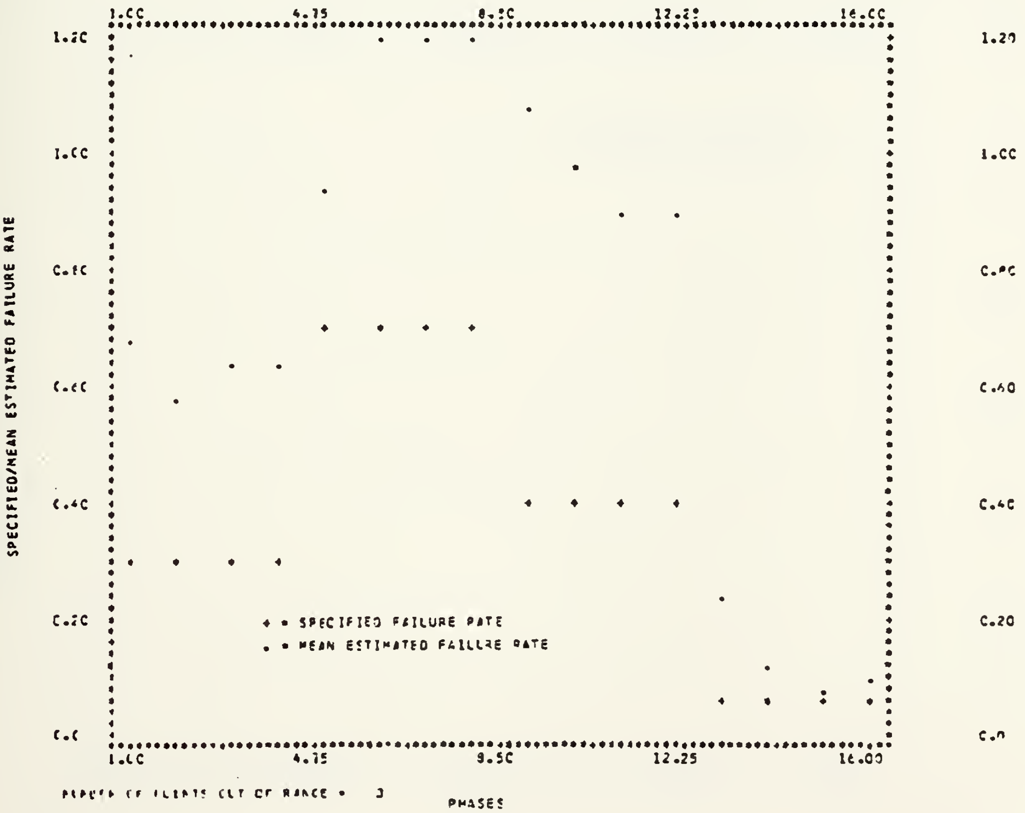


CASE 18

5 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.5417	0.5417	0.5417	0.5417	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	0.6856	0.5759	0.6478	0.6409	0.9320	1.2916	1.4142	1.5044
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	128.55	91.96	115.95	113.64	33.14	84.52	102.02	114.91
SAMPLE STD DEVIATION	0.3824	0.3068	0.3914	0.3941	0.6549	0.8306	0.8361	0.8525
CUMULATIVE TEST TIME	2.509	5.042	7.507	10.020	11.119	12.158	13.223	14.288
CUMULATIVE FAILURES	0.7100	1.3300	2.1800	2.7800	3.3600	4.2700	4.9600	5.5700

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	1.0843	0.9800	0.8954	0.9058	0.2407	0.1281	0.0862	0.0911
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	171.08	145.01	123.85	126.46	381.37	156.22	72.53	82.17
SAMPLE STD DEVIATION	0.8805	0.6514	0.6219	0.6619	0.3637	0.2458	0.1288	0.0750
CUMULATIVE TEST TIME	16.166	18.057	19.541	21.804	36.765	51.570	67.164	82.339
CUMULATIVE FAILURES	6.3900	7.4900	7.7700	8.6900	9.7800	10.3500	11.0900	11.7500



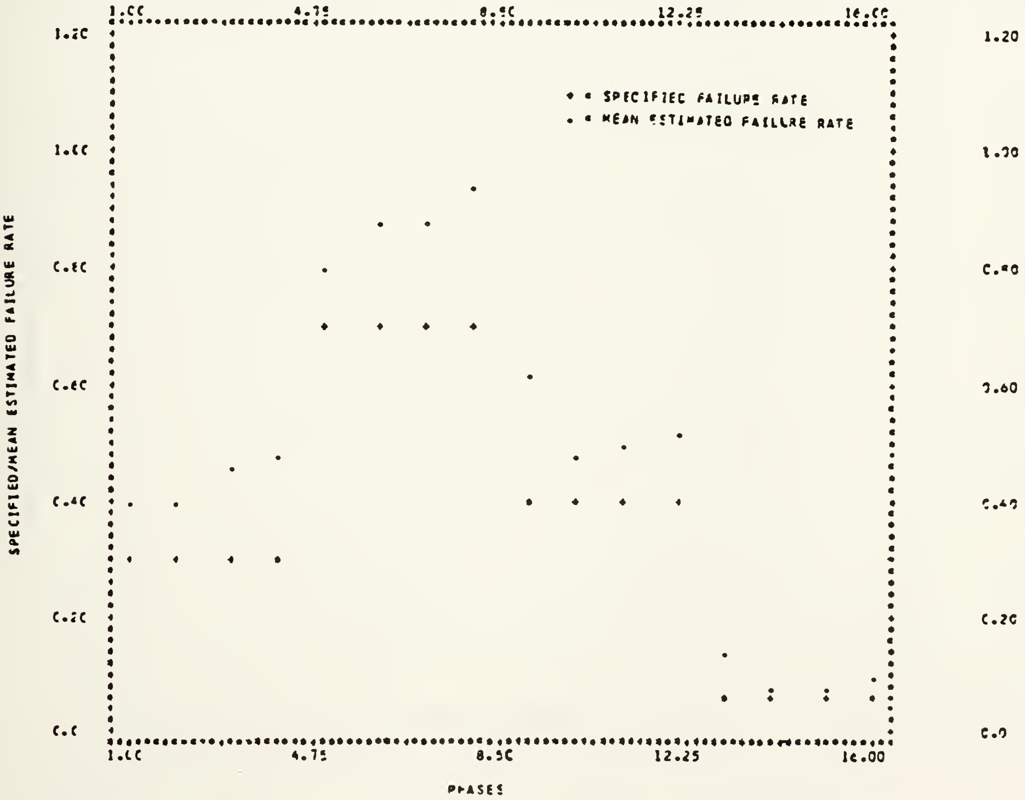
```
                                         CASE 18

                                         10 ITEMS

PHASE                          1          2          3          4          5          6          7          8
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.3000     0.3000     0.3000     0.3000     0.7000     0.7000     0.7000     0.7000
PLANNED  TEST  TIME       0.5417     0.5417     0.5417     0.5417     0.2322     0.2322     0.2322     0.2322
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.4091     0.3641     0.4504     0.4895     0.7903     0.8802     0.8770     0.9473
ESTIMATE  ERROR  AS        36.38      21.37      50.13      63.18      12.90      25.74      25.29      35.33
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.2150     0.2343     0.2807     0.2789     0.4813     0.6384     0.5285     0.5064
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       4.927      9.932     14.858     19.747     21.909     24.061     26.213     28.341
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.5900     2.9700     4.7300     6.5600     7.9700     9.0600    10.9100    12.4700
-----------------------------------------------------------------------------------------------------------------

*************************************************************************************************************************

PHASE                          9         10         11         12         13         14         15         16
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000     0.4000     0.4000     0.4000     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME       0.4063     0.4063     0.4063     0.4063     3.2504     3.2504     3.2504     3.2504
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.6132     0.4787     0.4953     0.5173     0.1325     0.0797     0.0700     0.0971
ESTIMATE  ERROR  AS        53.31      19.67      23.82      29.33     164.95      59.48      40.10      94.28
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.4347     0.3389     0.3316     0.3239     0.1755     0.1069     0.0671     0.2064
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      32.125     35.950     39.705     43.459     72.610    103.736    133.795    163.986
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      13.6700    15.0600    16.4200    17.6700    19.1700    20.8400    22.0400    23.4300
-----------------------------------------------------------------------------------------------------------------
```



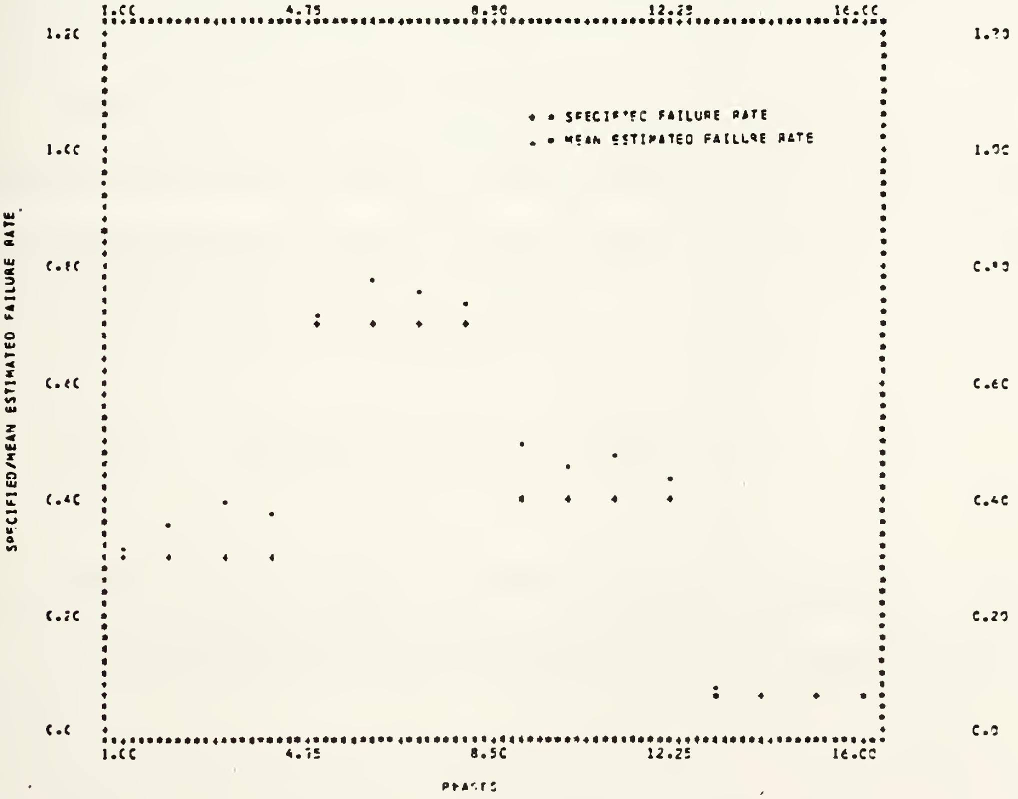
```
                                        CASE  18

                                        20 ITEMS


PHASE                          1         2         3         4         5         6         7         8
----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.3000    0.3000    0.3000    0.3000    0.7000    0.7000    0.7000    0.7000
PLANNED  TEST  TIME       0.5417    0.5417    0.5417    0.5417    0.2322    0.2322    0.2322    0.2322
----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.3215    0.3610    0.4089    0.3709    0.7200    0.7890    0.7526    0.7499
ESTIMATE  ERROR  AS         7.16     20.34     36.29     23.62      2.86     12.72      7.51      7.13
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.1815    0.3142    0.3177    0.2027    0.3510    0.4414    0.4237    0.2509
----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       9.956    19.986    29.890    39.908    44.206    48.415    52.744    57.039
----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       3.0300    5.9000    9.1800   12.0600   14.8100   17.9900   21.0300   23.9900
----------------------------------------------------------------------------------------------------------

..............................................................................................................

PHASE                          9        10        11        12        13        14        15        16
----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.4000    0.4000    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME       0.4063    0.4063    0.4063    0.4063    3.2504    3.2504    3.2504    3.2504
----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.5077    0.4640    0.4844    0.4414    0.0807    0.0547    0.0651    0.0619
ESTIMATE  ERROR  AS        26.92     16.01     21.11     10.35     61.50      9.36     30.29     23.80
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.3717    0.2441    0.2372    0.2281    0.0813    0.0250    0.0366    0.0350
----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      64.569    72.091    79.547    87.057   147.563   208.236   267.136   327.873
----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      26.9100   29.8600   33.1100   36.0300   38.8100   41.5400   44.6200   47.5000
----------------------------------------------------------------------------------------------------------
```



APPENDIX E

Results of Test MOD3

1. Test MOD3

Test MOD3 used the AMSAA model to estimate the failure rate of the items tested except as described below. A more detailed discussion of the modification can be found in Section V-D.

Use of the AMSAA model was modified as follows:

a. The point estimate of the failure rate,

$$r_p = \frac{\text{number of failures during a phase}}{\text{total test time during a phase}} ,$$

was used whenever cumulative test time over all items was less than 10 hours.

b. The slope of the reliability growth pattern was estimated using the current point estimate, r_p, and the two previous estimates of the failure rate, $\hat{r}_{i-1}$ and $\hat{r}_{i-2}$. The slope estimated was in two parts,

$$\hat{r}_{i-1} - \hat{r}_{i-2} \quad \text{and} \quad r_p - \hat{r}_{i-1} .$$

The estimate of the slope was considered increasing if both parts of the estimate were determined to be increasing as follows:

$$\hat{r}_{i-1} - \hat{r}_{i-2} \geq ,07$$

and

$$r_p - \hat{r}_{i-1} \geq .07 \quad .$$

If the slope was increasing, the point estimate, r_p, was used as the current estimate of the failure rate. Then, the AMSAA model was reinitialized, that is, time and failures prior to an increasing slope were not considered in future estimates made by the model.

2. The Results

Results for Cases 4, 6, 15, and 18 are presented here as representative of the effect the modifications had on the performance of the model. A detailed description of the format of the results can be found in Appendix A.

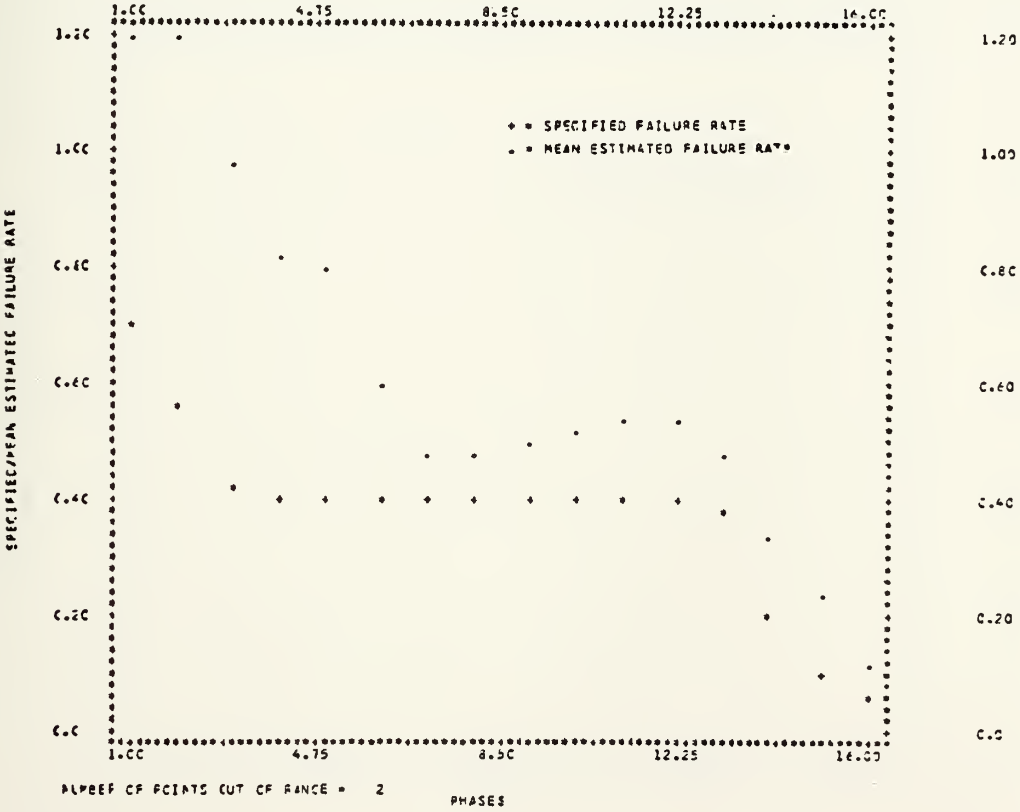
```
                                          CASE   4

                                          5 ITEMS

PHASE                         1          2          3          4          5          6          7          8
---------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000     0.5500     0.4250     0.4050     0.4000     0.4000     0.4000     0.4000
PLANNED  TEST  TIME         0.2322     0.2555     0.3824     0.4013     0.4063     0.4063     0.4063     0.4063
---------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             1.3264     1.2500     0.9888     0.8127     0.8044     0.6062     0.4842     0.4785
ESTIMATE  ERROR  AS          89.49     134.54     132.65     100.68     101.09      51.55      21.06      19.63
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.6578     0.7356     0.6517     0.4575     0.4637     0.5258     0.3180     0.2967
---------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         1.074      2.418      4.202      6.049      7.942      9.843     11.697     13.580
---------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.6400     1.5100     2.0700     2.5100     3.3500     4.2700     5.0700     5.7700
---------------------------------------------------------------------------------------------------------------

*****************************************************************************************************************

PHASE                         9         10         11         12         13         14         15         16
---------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.4000     0.4000     0.4000     0.4000     0.3750     0.2000     0.1000     0.0500
PLANNED  TEST  TIME         0.4063     0.4063     0.4063     0.4063     0.4334     0.8126     1.6252     3.2504
---------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.5034     0.5153     0.5353     0.5432     0.4831     0.3456     0.2457     0.1275
ESTIMATE  ERROR  AS          25.85      28.83      33.81      35.79      28.83      72.82     145.66     154.57
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.3057     0.3314     0.3348     0.3906     0.3209     0.2252     0.2752     0.0814
---------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        15.442     17.319     19.186     21.049     23.079     26.860     34.326     45.304
---------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         6.5800     7.3000     8.0700     8.3700     9.3200    10.0800    10.8500    11.5000
---------------------------------------------------------------------------------------------------------------
```



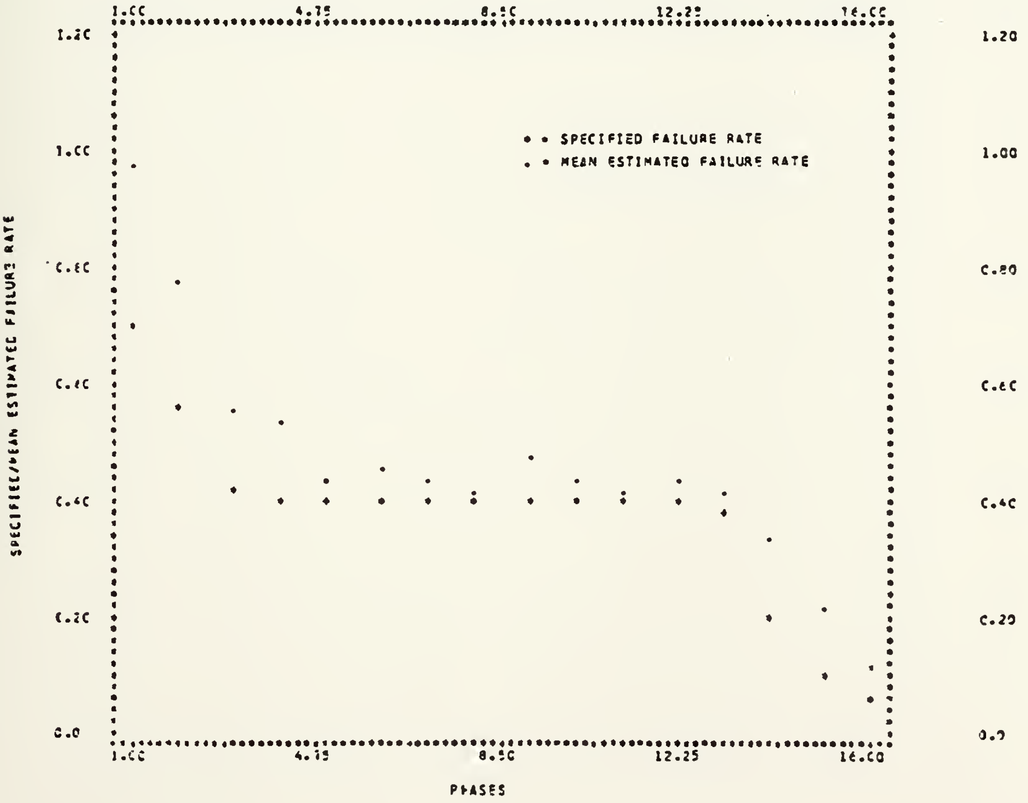
```
                                          CASE   4

                                          10 ITEMS

PHASE                          1          2          3          4          5          6          7          8
-------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000     0.5500     0.4250     0.4050     0.4000     0.4000     0.4000     0.4000
PLANNED  TEST  TIME         0.2322     0.2555     0.3624     0.4013     0.4063     0.4063     0.4063     0.4063
-------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.9739     0.7761     0.5674     0.5432     0.4428     0.4551     0.4391     0.4316
ESTIMATE  ERROR  AS          39.13      41.11      33.50      34.13      10.71      13.77       9.77       7.90
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.6085     0.5434     0.3315     0.5243     0.2595     0.2514     0.2879     0.2209
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         2.136      4.687      8.462     12.133     15.883     19.633     23.410     27.195
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         1.5400     2.9400     4.1400     5.8600     7.3100     8.6400    10.1000    11.3900
-------------------------------------------------------------------------------------------------------------------


*************************************************************************************************************************

PHASE                          9         10         11         12         13         14         15         16
-------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.4000     0.4000     0.4000     0.4000     0.3750     0.2000     0.1000     0.0500
PLANNED  TEST  TIME         0.4063     0.4063     0.4063     0.4063     0.4334     0.8126     1.6252     3.2504
-------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.4859     0.4394     0.4195     0.4398     0.4265     0.3421     0.2276     0.1265
ESTIMATE  ERROR  AS          21.47       9.86       4.87       9.94      13.73      71.06     127.63     152.99
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.3373     0.2938     0.2260     0.2441     0.1972     0.1964     0.0938     0.0404
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        30.943     34.723     38.459     42.187     46.178     53.627     68.565     98.301
-------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        13.0700    14.3100    16.0100    17.5700    19.1600    20.8000    22.3600    23.9370
-------------------------------------------------------------------------------------------------------------------
```



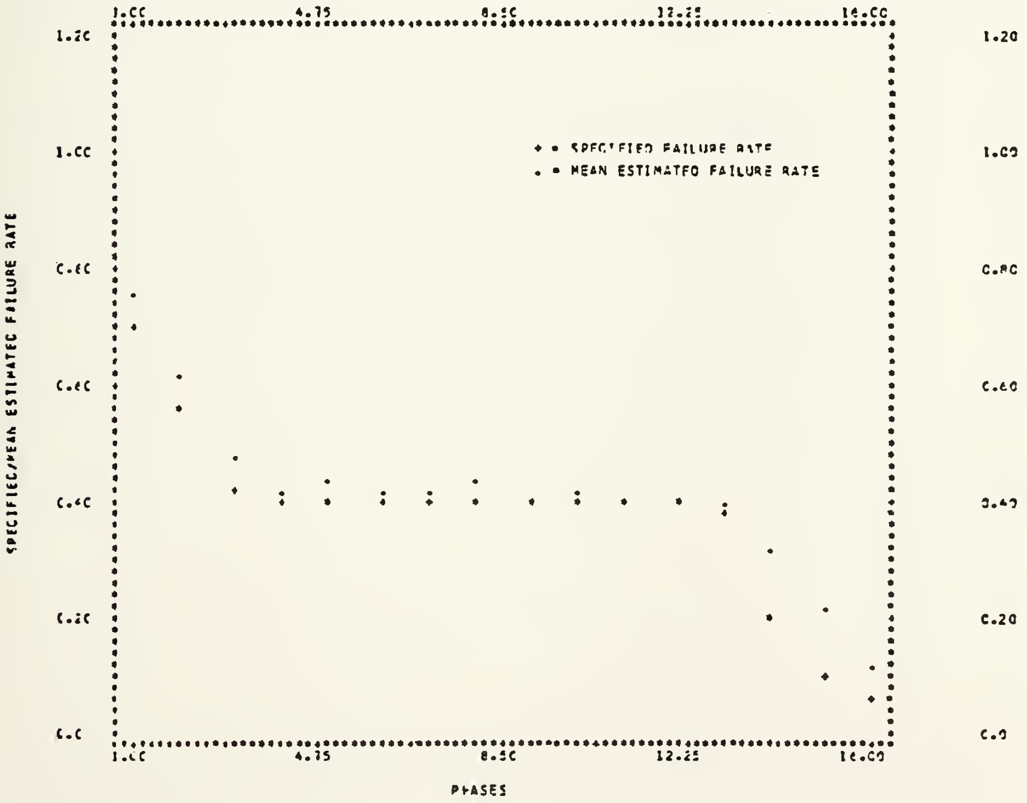
```
                                   CASE   4

                                   20 ITEMS

PHASE                         1        2        3        4        5        6        7        8
-----------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000   0.5500   0.4250   0.4050   0.4000   0.4000   0.4000   0.4000
ELAPSED  TEST  TIME      0.2322   0.2525   0.3824   0.4013   0.4063   0.4063   0.4063   0.4063
-----------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.7576   0.6289   0.4737   0.4292   0.4348   0.4294   0.4121   0.4330
ESTIMATE  ERROR  AS        8.23    14.35    11.47     5.98     8.71     7.35     3.03     8.25
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.4180   0.3368   0.2465   0.2077   0.2363   0.2052   0.1562   0.1784
-----------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      4.213    9.758   16.874   24.303   31.798   39.227   46.755   54.188
-----------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      2.9500   5.8600   8.8100  11.7100  14.7100  17.7600  20.8300  24.0300
-----------------------------------------------------------------------------------------------

***************************************************************************************************

PHASE                         9       10       11       12       13       14       15       16
-----------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.4000   0.4000   0.4000   0.4000   0.3750   0.2000   0.1000   0.0500
ELAPSED  TEST  TIME      0.4063   0.4063   0.4063   0.4063   0.4334   0.8126   1.6252   3.2504
-----------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.4096   0.4167   0.3936   0.3958   0.3913   0.3106   0.2133   0.1268
ESTIMATE  ERROR  AS        2.39     4.17     1.59     1.04     4.34    55.31   113.25   152.63
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.1433   0.1600   0.1282   0.1137   0.1154   0.0939   0.0667   0.0406
-----------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     61.676   69.133   76.672   84.172   92.154  107.154  137.320  197.432
-----------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     27.0400  30.2200  33.2300  36.1700  39.0600  42.0600  44.8000  47.8000
-----------------------------------------------------------------------------------------------
```

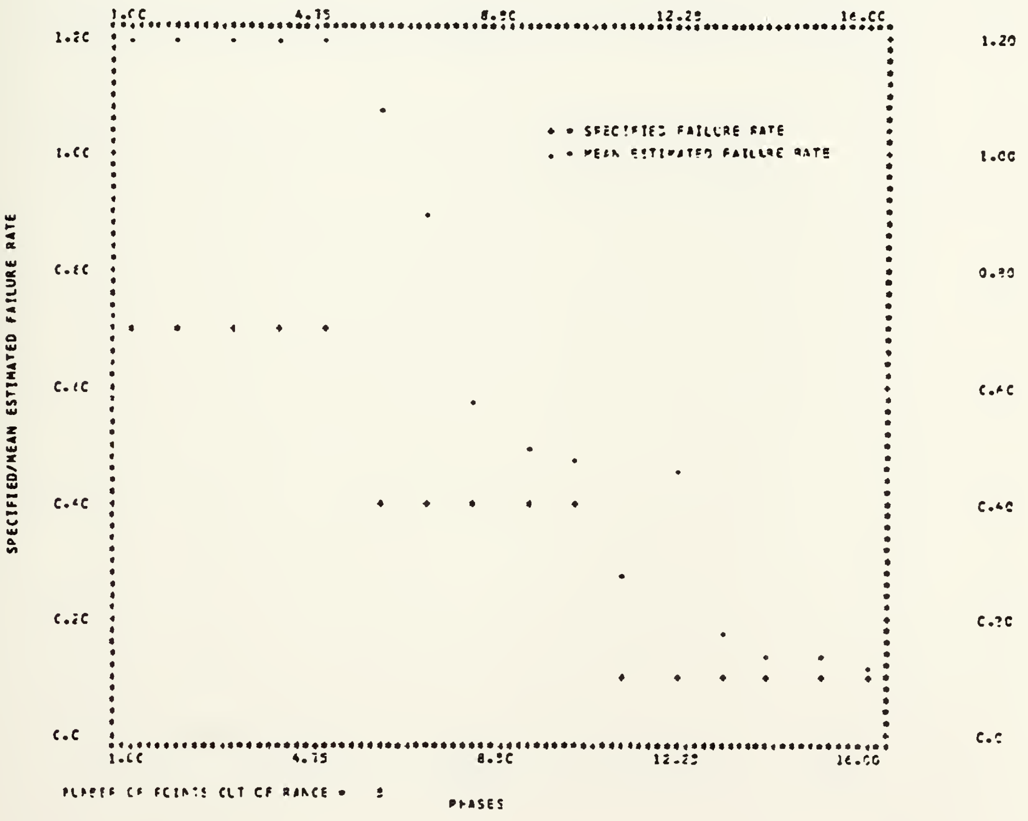


CASE 6

5 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.7000	0.7000	0.4000	0.4000	0.4000
PLANNED TEST TIME	0.2322	0.2322	0.2322	0.2322	0.2322	0.4063	0.4063	0.4063
MODEL ESTIMATE	1.3652	1.4414	1.3728	1.4248	1.3555	1.0810	0.9029	0.5731
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	95.03	105.91	96.11	103.54	93.64	170.24	125.72	43.27
SAMPLE STD DEVIATION	0.6434	0.8235	0.7410	0.7812	0.6901	0.7164	0.6255	0.2565
CUMULATIVE TEST TIME	1.061	2.128	3.209	4.305	5.374	7.310	9.075	10.968
CUMULATIVE FAILURES	0.7400	1.4900	2.2200	2.8400	3.5500	4.4300	5.2900	6.0100

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.4063	0.4063	1.6252	1.6252	1.6252	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.5098	0.4751	0.2701	0.4624	0.1733	0.1458	0.1340	0.1231
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	27.46	18.77	170.15	362.37	73.29	45.78	33.96	23.08
SAMPLE STD DEVIATION	0.2718	0.2446	0.1674	2.5930	0.1390	0.1051	0.0751	0.0545
CUMULATIVE TEST TIME	12.856	14.742	22.241	29.722	37.201	44.676	52.044	59.523
CUMULATIVE FAILURES	6.6800	7.3800	7.9800	8.9000	9.7000	10.4000	11.3000	12.1500



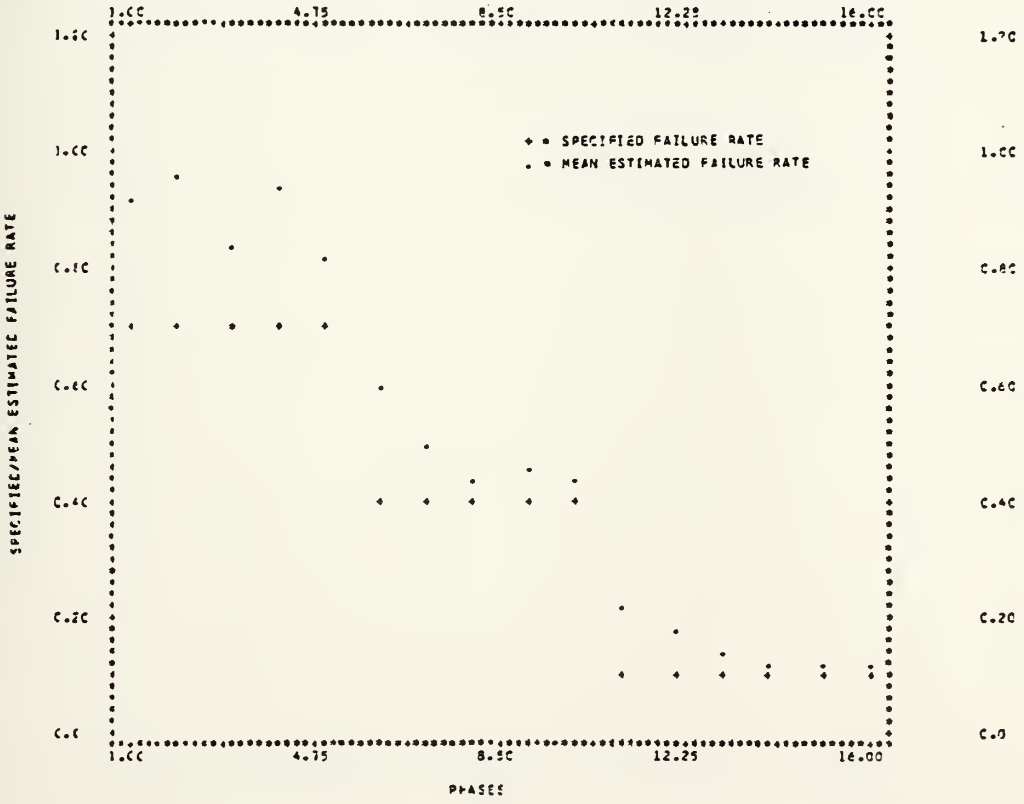
```
                                        CASE   6

                                        10 ITEMS

PHASE                            1         2         3         4         5         6         7         8
-------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME         0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
-------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.9192    0.9590    0.8363    0.9337    0.8286    0.6061    0.5078    0.4483
ESTIMATE  ERROR  AS          31.32     37.00     19.48     33.38     18.37     51.53     26.95     12.08
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.5075    0.5522    0.4067    0.4841    0.4354    0.3851    0.3397    0.2194
-------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         2.158     4.277     6.441     8.553    10.725    14.459    18.287    22.093
-------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         1.3900    3.0100    4.3300    5.5200    7.1800    8.6600    9.9800   11.2500
-------------------------------------------------------------------------------------------------------------

*****************************************************************************************************************

PHASE                            9        10        11        12        13        14        15        16
-------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME         0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
-------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.4693    0.4462    0.2259    0.1702    0.1426    0.1266    0.1167    0.1107
ESTIMATE  ERROR  AS          17.32     11.54    125.59     70.15     42.63     26.58     16.68     10.70
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.2712    0.2156    0.0906    0.0626    0.0517    0.0458    0.0357    0.0335
-------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        25.831    29.965    44.552    59.418    74.438    89.320   104.331   119.306
-------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        12.7500   14.1500   15.7600   17.4500   19.0200   20.5800   22.1800   23.7400
-------------------------------------------------------------------------------------------------------------
```



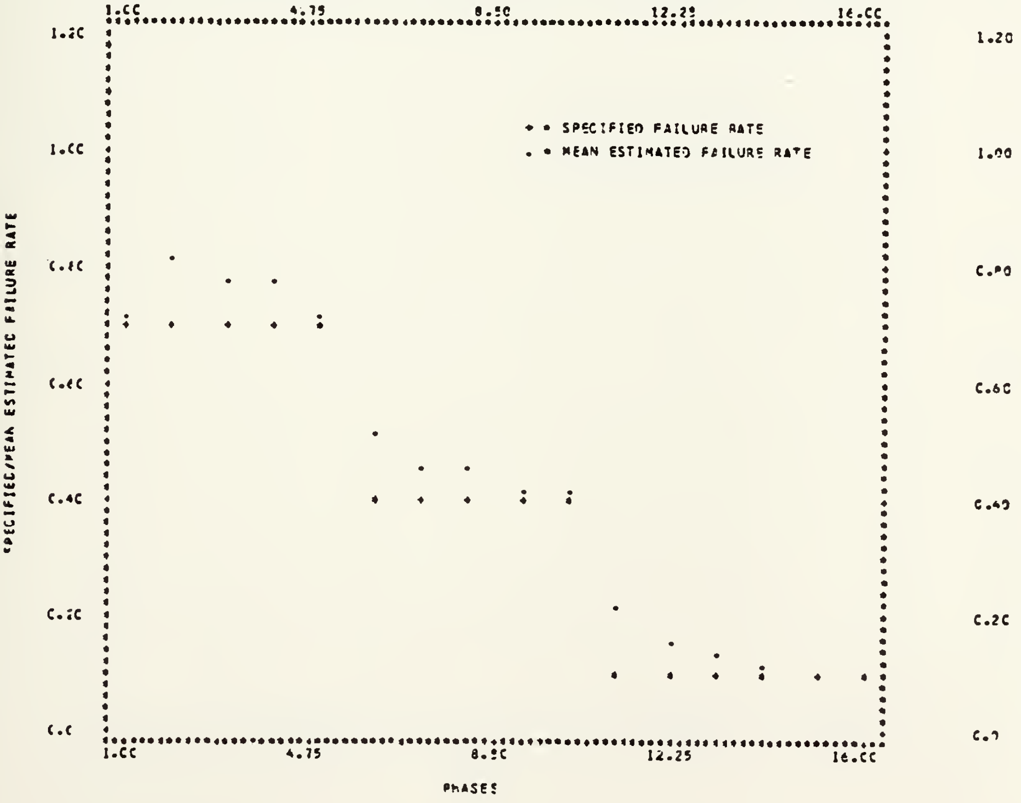
```
                                        CASE   6

                                        20 ITEMS

PHASE                           1         2         3         4         5         6         7         8
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME        0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            0.7251    0.8111    0.7828    0.7842    0.7198    0.5260    0.4614    0.4536
ESTIMATE  ERROR  AS          3.58     15.86     11.82     12.02      2.82     31.49     15.35     13.40
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.4087    0.4101    0.3489    0.3558    0.3222    0.2321    0.1817    0.1604
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        4.294     8.561    12.842    17.130    21.419    28.905    36.410    43.831
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        2.7700    6.0500    9.2000   12.3000   15.2100   17.8500   21.0200   24.3000
-----------------------------------------------------------------------------------------------------------

*************************************************************************************************************

PHASE                           9        10        11        12        13        14        15        16
-----------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME        0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
-----------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            0.4173    0.4176    0.2115    0.1607    0.1338    0.1181    0.1081    0.1009
ESTIMATE  ERROR  AS          4.33      4.39    111.52     60.74     33.84     18.06      8.09      0.94
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.1407    0.1426    0.0741    0.0457    0.0339    0.0273    0.0235    0.0204
-----------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       51.373    58.856    88.818   118.457   148.459   178.319   208.549   238.637
-----------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       27.0300   30.0600   33.1700   36.4600   39.4300   42.3900   45.2600   48.2200
-----------------------------------------------------------------------------------------------------------
```



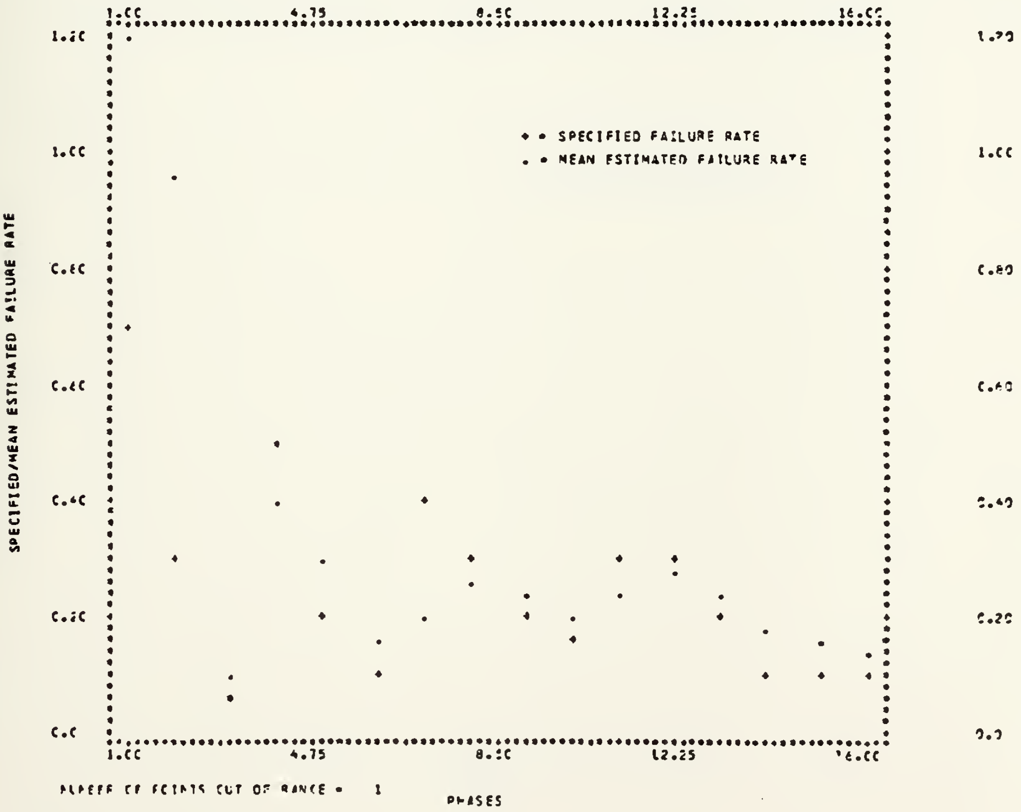
```
                                      CASE  15

                                      5 ITEMS

PHASE                        1         2         3         4         5         6         7         8
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.3000    0.0500    0.5000    0.2000    0.1000    0.4000    0.3000
PLANNED  TEST  TIME       0.2322    0.5417    3.2504    0.3750    0.8126    1.6252    0.4063    0.5417
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           1.5230    0.9539    0.1074    0.4027    0.2942    0.1574    0.1924    0.2619
ESTIMATE  ERROR  AS       117.57    217.97    114.79     19.47     47.10     57.40     51.89     12.70
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      1.0093    0.8239    0.1107    0.7404    0.3842    0.1725    0.1968    0.3440
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       1.074     3.573    18.481    19.990    23.722    31.225    33.112    35.575
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       0.7500    1.5200    2.2500    2.9500    3.7300    4.4500    5.0700    5.5300
--------------------------------------------------------------------------------------------------------

****************************************************************************************************************

PHASE                        9        10        11        12        13        14        15        16
--------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.2000    0.1500    0.3000    0.3000    0.2000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME       0.8126    1.0835    0.5417    0.5417    0.8126    1.6252    1.6252    1.6252
--------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.2333    0.1928    0.2456    0.2727    0.2409    0.1834    0.1318    0.1314
ESTIMATE  ERROR  AS        16.63     28.51     18.13      9.09     20.47     83.40     31.75     31.43
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.2264    0.1616    0.2381    0.2768    0.2453    0.1259    0.0997    0.0811
--------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      39.351    44.283    46.786    49.254    53.005    60.484    68.097    75.729
--------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       6.5100    7.2200    8.3100    9.1000    9.8100   10.7100   11.3500   11.9500
--------------------------------------------------------------------------------------------------------
```

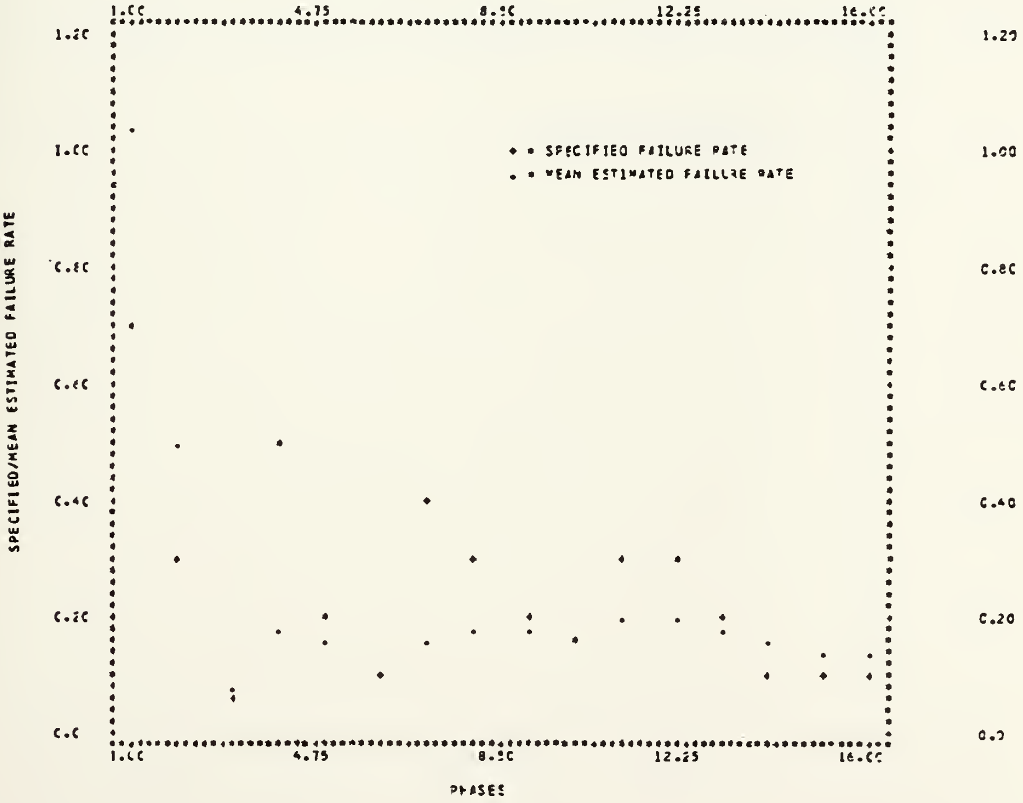


CASE 15

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.3000	0.0500	0.5000	0.2000	0.1000	0.4000	0.3000
PLANNED TEST TIME	0.2322	0.5417	3.2504	0.3250	0.8126	1.6252	0.4063	0.5417
MODEL ESTIMATE	1.0292	0.5081	0.0843	0.1876	0.1503	0.1072	0.1500	0.1721
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	48.46	65.36	68.63	62.49	24.85	7.18	62.49	42.64
SAMPLE STD DEVIATION	0.5388	0.3629	0.1227	0.3933	0.1465	0.0610	0.1129	0.1137
CUMULATIVE TEST TIME	2.104	7.083	37.101	40.105	47.606	62.376	66.304	71.262
CUMULATIVE FAILURES	1.7700	3.3500	4.8500	6.3500	7.9200	9.3800	10.9800	12.5900

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.2000	0.1500	0.3000	0.3000	0.2000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.8126	1.0835	0.5417	0.5417	0.8126	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.1801	0.1664	0.1985	0.1981	0.1861	0.1584	0.1447	0.1338
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	9.93	10.93	33.85	33.96	6.94	58.38	44.71	33.81
SAMPLE STD DEVIATION	0.1424	0.1109	0.1573	0.1275	0.0857	0.0606	0.0531	0.0473
CUMULATIVE TEST TIME	78.788	88.725	93.707	98.702	106.248	121.305	136.237	151.192
CUMULATIVE FAILURES	13.9900	15.5700	17.1800	18.6800	20.1100	21.6400	23.2900	24.8700



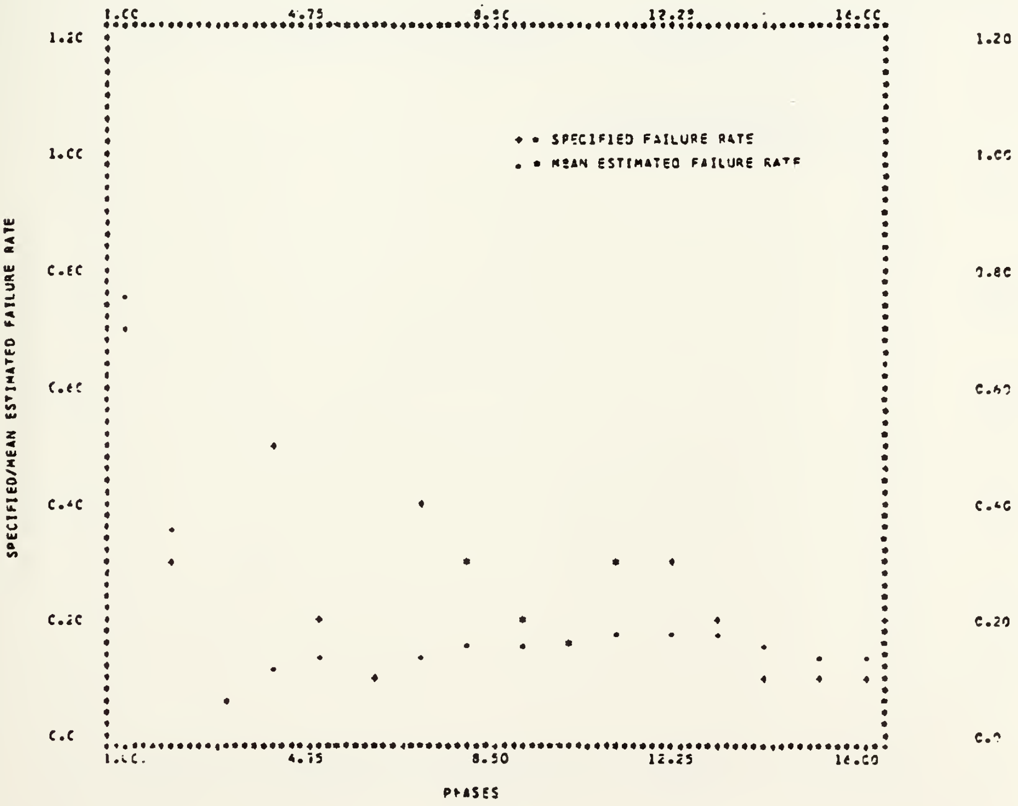
CASE 15

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.3000	0.0500	0.5000	0.2000	0.1000	0.4000	0.3000
PLANNED TEST TIME	0.2322	0.5417	3.2504	0.3250	0.8126	1.6252	0.4063	0.5417
MODEL ESTIMATE	0.7622	0.3512	0.0627	0.1195	0.1367	0.1065	0.1434	0.1673
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	8.89	17.05	25.32	76.02	31.66	6.54	64.15	44.22
SAMPLE STD DEVIATION	0.4209	0.1582	0.0377	0.2004	0.1081	0.0469	0.0840	0.0504
CUMULATIVE TEST TIME	4.272	14.268	74.066	80.098	95.034	124.511	132.346	142.278
CUMULATIVE FAILURES	2.9500	5.8500	9.0000	11.7600	14.8800	18.0500	21.3200	24.4500

****

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.2000	0.1500	0.3000	0.3000	0.2000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.8126	1.0835	0.5417	0.5417	0.8126	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.1652	0.1573	0.1769	0.1884	0.1869	0.1642	0.1479	0.1370
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	15.41	4.85	41.05	37.19	6.55	64.17	47.93	37.04
SAMPLE STD DEVIATION	0.0510	0.0606	0.0896	0.0683	0.0616	0.0454	0.0363	0.0320
CUMULATIVE TEST TIME	157.243	177.242	187.247	197.196	212.194	242.173	272.258	302.306
CUMULATIVE FAILURES	27.4000	30.4200	33.4100	36.6600	39.6100	42.6600	45.4900	48.4300



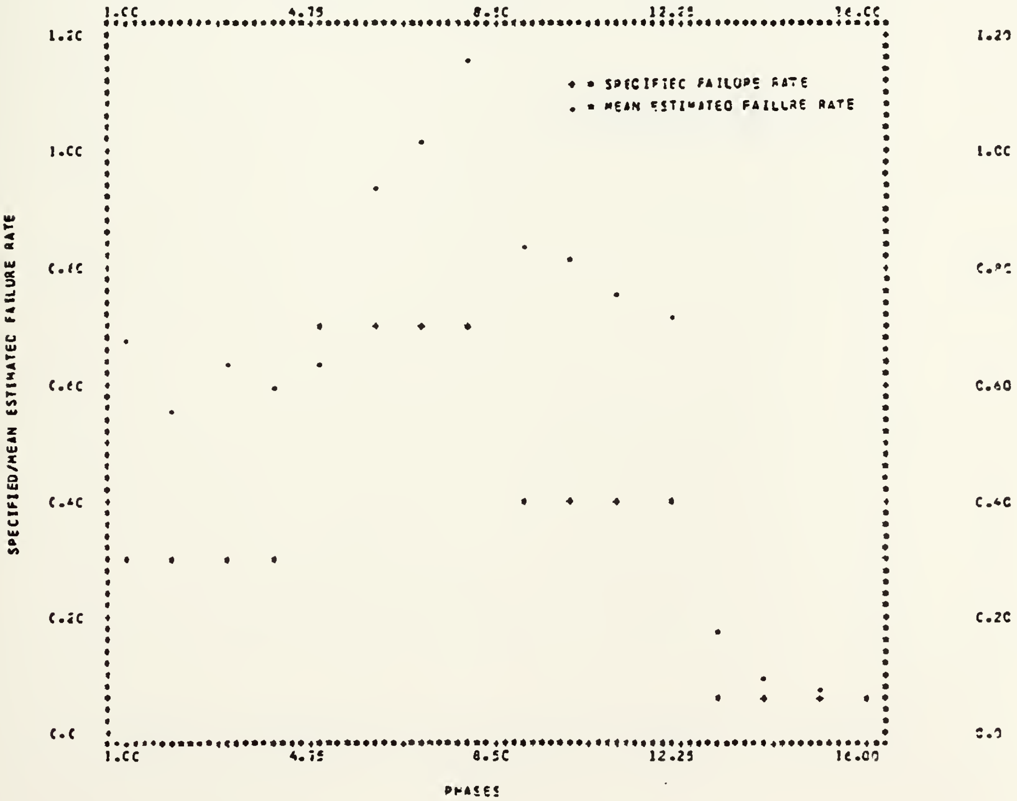
```
                                        CASE  1B

                                        5 ITEMS

PHASE                            1          2          3          4          5          6          7          8
--------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.3000     0.3000     0.3000     0.3000     0.7000     0.7000     0.7000     0.7000
PLANNED  TEST  TIME         0.5417     0.5417     0.5417     0.5417     0.2322     0.2322     0.2327     0.2327
--------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.6856     0.5667     0.6452     0.5939     0.6399     0.9478     1.0259     1.1455
ESTIMATE  ERROR  AS         128.55      88.90     115.06      97.97       8.59      35.40      46.56      63.64
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.3824     0.3011     0.3577     0.4844     0.7454     0.8715     0.7923     0.8855
--------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         2.505      5.042      7.507     10.020     11.115     12.158     13.223     14.288
--------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         0.7100     1.4200     2.2600     2.9000     3.4200     4.4700     5.0300     5.5100
--------------------------------------------------------------------------------------------------------------------

......................................................................................................................

PHASE                            9         10         11         12         13         14         15         16
--------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE         0.4000     0.4000     0.4000     0.4000     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME         0.4063     0.4063     0.4063     0.4063     3.2504     3.2504     3.2504     3.2504
--------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE             0.8375     0.8294     0.7519     0.7233     0.1743     0.1005     0.0784     0.0604
ESTIMATE  ERROR  AS         109.37     107.36      87.98      80.82     248.68     101.05      56.86      20.87
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION        0.6796     0.6606     0.6110     0.5380     0.1542     0.0655     0.0513     0.0282
--------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        16.166     18.057     19.941     21.804     36.765     51.970     67.164     82.335
--------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         6.8200     7.5300     8.2700     8.9800     9.9200    10.4800    11.2000    11.5100
--------------------------------------------------------------------------------------------------------------------
```

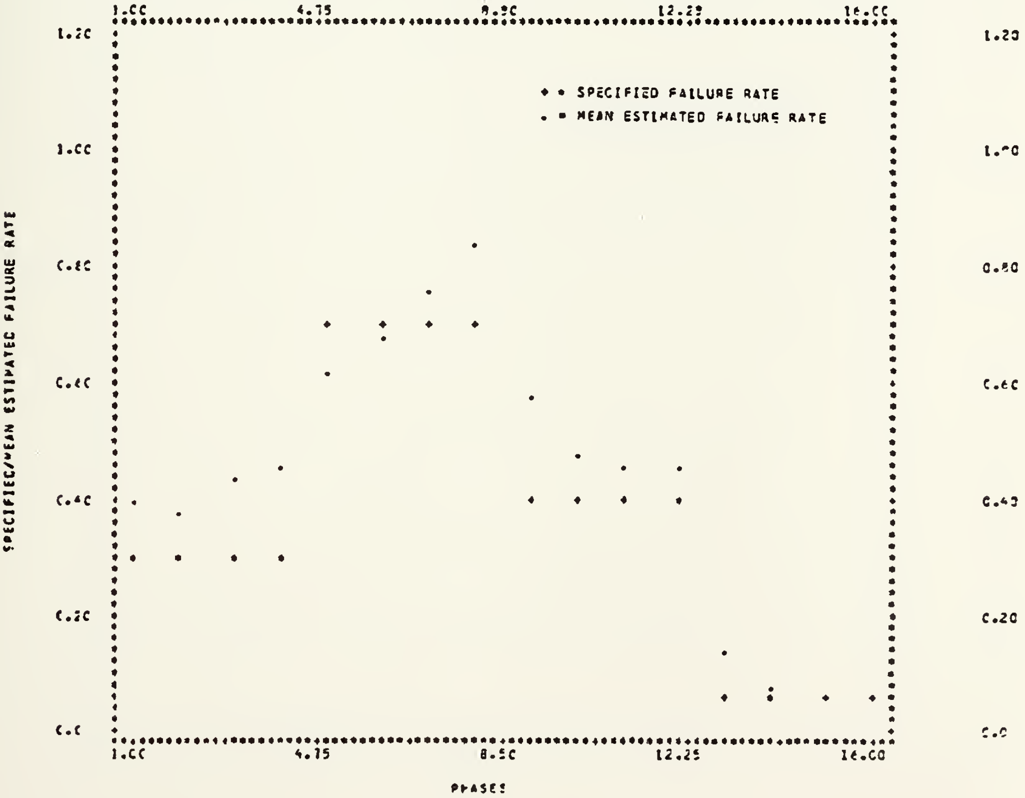


CASE 18

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.3000	0.3000	0.3000	0.3000	0.7000	0.7000	0.7000	0.7000
PLANNED TEST TIME	0.5417	0.5417	0.5417	0.5417	0.2322	0.2322	0.2322	0.2322
MODEL ESTIMATE	0.4091	0.3816	0.4460	0.4523	0.6225	0.6775	0.7650	0.8337
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	36.38	27.19	48.68	50.77	11.07	3.21	9.28	19.10
SAMPLE STD DEVIATION	0.2150	0.2724	0.3171	0.2569	0.4405	0.4133	0.5224	0.4772
CUMULATIVE TEST TIME	4.527	9.532	14.858	19.747	21.905	24.061	26.213	28.341
CUMULATIVE FAILURES	1.5500	3.0400	4.7600	6.5600	7.9700	9.1400	10.4800	12.4700

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.0500	0.0500	0.0500	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	3.2504	3.2504	3.2504	3.2504
MODEL ESTIMATE	0.5821	0.4701	0.4579	0.4509	0.1327	0.0862	0.0678	0.0588
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	45.54	17.53	14.48	12.74	165.48	72.45	35.66	17.67
SAMPLE STD DEVIATION	0.3305	0.1858	0.2051	0.2147	0.0628	0.0355	0.0283	0.0224
CUMULATIVE TEST TIME	32.125	35.550	39.705	43.455	73.610	103.736	133.755	163.986
CUMULATIVE FAILURES	13.8200	15.0600	16.5500	18.0700	19.4800	20.8400	22.3300	23.8700



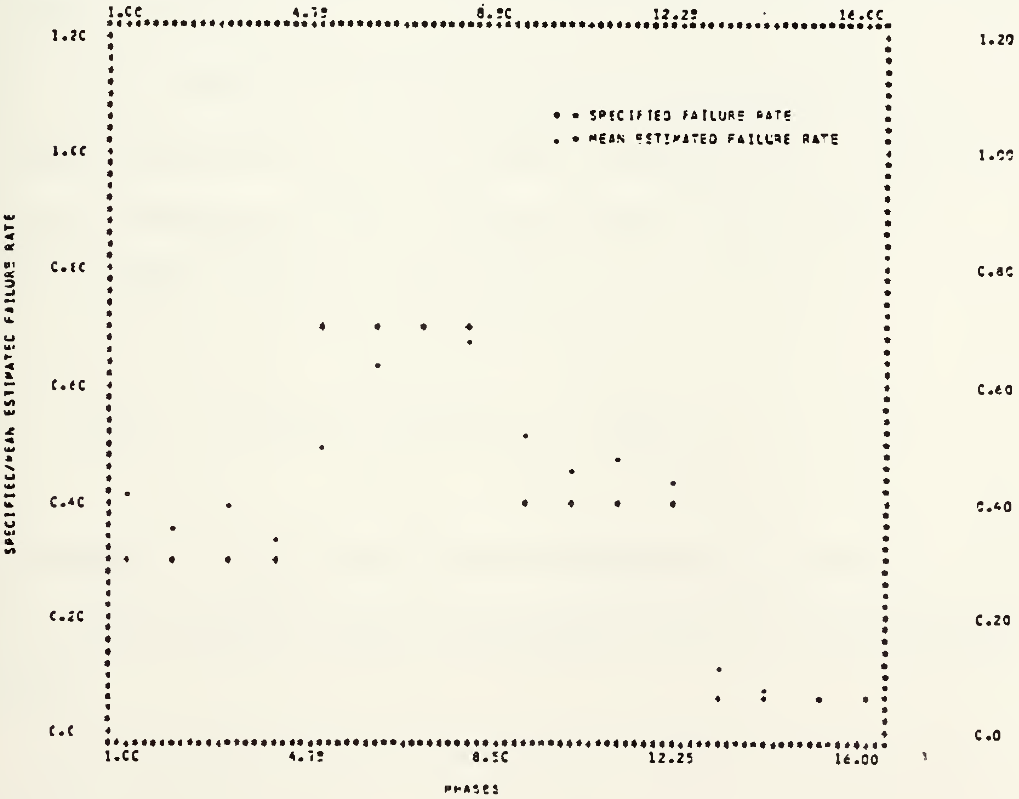
```
                                       CASE  18

                                       20 ITEMS

PHASE                        1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.3000    0.3000    0.3000    0.3000    0.7000    0.7000    0.7000    0.7000
PLANNED  TEST  TIME     0.5417    0.5417    0.5417    0.5417    0.2222    0.2222    0.2222    0.2222
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.4185    0.3643    0.3517    0.3462    0.4536    0.6321    0.6954    0.6863
ESTIMATE  ERROR  AS      39.49     21.43     30.58     15.39     35.49      9.70      0.68      1.96
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.2505    0.2188    0.3011    0.1619    0.2950    0.3163    0.3562    0.3376
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     9.556    19.586    29.890    39.508    44.206    48.475    52.744    57.035
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     3.0300    5.5000    9.1800   12.0600   14.9400   18.1200   21.0300   23.9900
------------------------------------------------------------------------------------------------------

**************************************************************************************************************

PHASE                        9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE     0.4000    0.4000    0.4000    0.4000    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME     0.4063    0.4063    0.4063    0.4063    3.2504    3.2504    3.2504    3.2504
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE         0.5218    0.4624    0.4861    0.4394    0.1257    0.0794    0.0642    0.0553
ESTIMATE  ERROR  AS      30.44     15.60     21.53      9.86   -155.33     58.89     28.34     10.51
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION    0.2717    0.2251    0.2259    0.1740    0.0792    0.0341    0.0242    0.0183
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME    64.569    72.091    79.547    87.097   147.563   208.236   267.736   327.823
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES    26.9100   29.8600   33.1100   36.0300   38.5000   41.5400   44.6200   47.5000
------------------------------------------------------------------------------------------------------
```



APPENDIX F

Results of Test MOD4

1. Test MOD4

Test MOD4 used the AMSAA model to estimate the failure rate of the items tested except as described below. A more detailed discussion of the modification can be found in Section V-D.

Use of the AMSAA model was modified as follows:

a. The point estimate of the failure rate,

$$r_p = \frac{\text{number of failures during a phase}}{\text{total test time during a phase}} ,$$

was used whenever cumulative test time over all items was less than 10 hours.

b. The slope of the reliability growth pattern was estimated using the current point estimate, r_p, and the previous estimates of the failure rate, $\hat{r}_{i-1}$ and $\hat{r}_{i-2}$. The slope estimated was in two parts,

$$\hat{r}_{i-1} - \hat{r}_{i-2} \quad \text{and} \quad r_p - \hat{r}_{i-1} \quad .$$

The estimate of the slope was considered increasing if both parts of the estimate were determined to be increasing as follows:

$$\hat{r}_{i-1} - \hat{r}_{i-2} \geq .2\hat{r}_{i-2}$$

and

$$r_p - \hat{r}_{i-1} \geq .2\hat{r}_{i-1} \quad .$$

If the slope was increasing, the point estimate, r_p, was used as the current estimate of the failure rate. Then, the AMSAA model was reinitialized, that is, time and failures prior to an increasing slope were not considered in future estimates made by the model.

2. The Results

Results for Cases 4, 6, 15, and 18 are presented here as representative of the effect the modifications had on the performance of the model. A detailed description of the format of the results can be found in Appendix A.

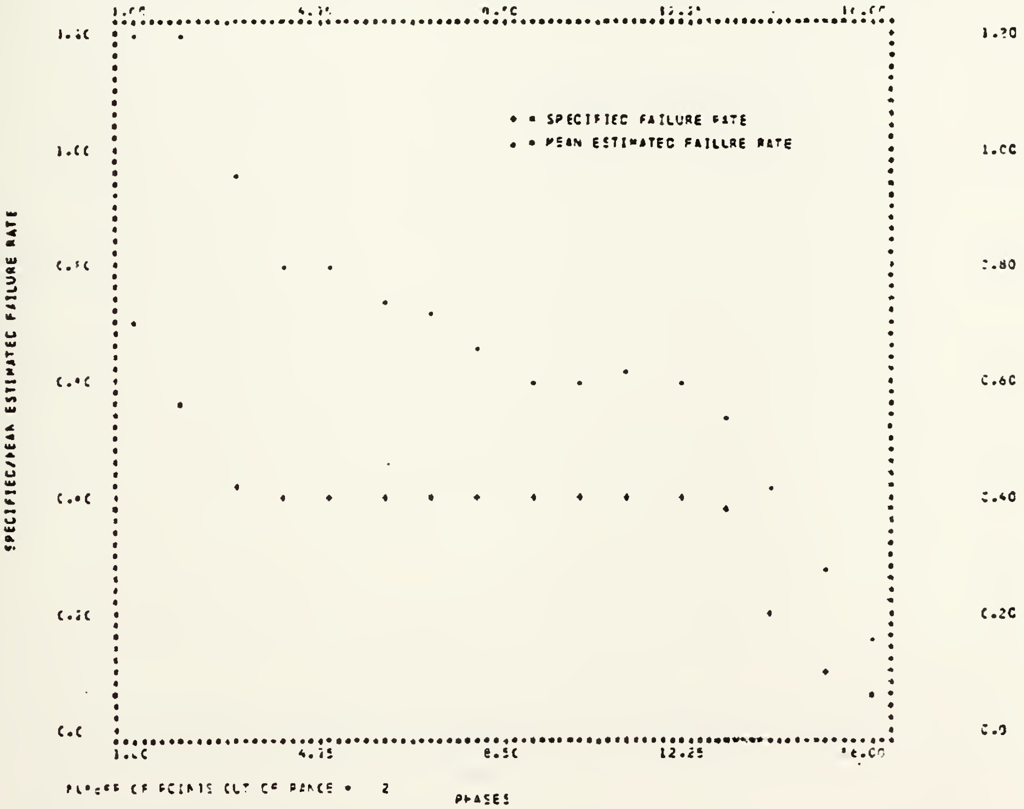
```
                                         CASE   4

                                         5 ITEMS

PHASE                            1          2          3          4          5          6          7          8
------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.7000     0.5500     0.4250     0.4050     0.4000     0.4000     0.4000     0.4000
PLANNED  TEST  TIME          0.2322     0.2955     0.3824     0.4013     0.4063     0.4063     0.4063     0.4063
------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              1.3264     1.3186     0.9675     0.8075     0.8067     0.7440     0.7156     0.6506
ESTIMATE  ERROR  AS           89.49     139.74     127.64      99.37     101.68      86.01      78.89      62.66
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         0.6978     0.7415     0.6545     0.4593     0.4655     0.4814     0.5957     0.4663
------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME          1.074      2.418      4.202      6.049      7.942      9.843     11.697     13.580
------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          0.6400     1.4300     2.0500     2.8900     3.5500     4.2300     5.0400     5.7700
------------------------------------------------------------------------------------------------------------------

**********************************************************************************************************************

PHASE                            9         10         11         12         13         14         15         16
------------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.4000     0.4000     0.4000     0.4000     0.3750     0.2000     0.1000     0.0500
PLANNED  TEST  TIME          0.4063     0.4063     0.4063     0.4063     0.4334     0.8126     1.6252     3.2504
------------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              0.6016     0.6015     0.6177     0.5977     0.5446     0.4120     0.2700     0.1532
ESTIMATE  ERROR  AS           50.41      50.37      54.43      49.43      45.24     106.01     170.01     206.46
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         0.3664     0.3963     0.3634     0.3770     0.3406     0.2573     0.2077     0.1437
------------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         15.442     17.319     19.186     21.049     23.079     26.880     34.336     49.304
------------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          6.5800     7.2600     8.0000     8.6900     9.2300    10.0100    10.8500    11.6400
------------------------------------------------------------------------------------------------------------------
```



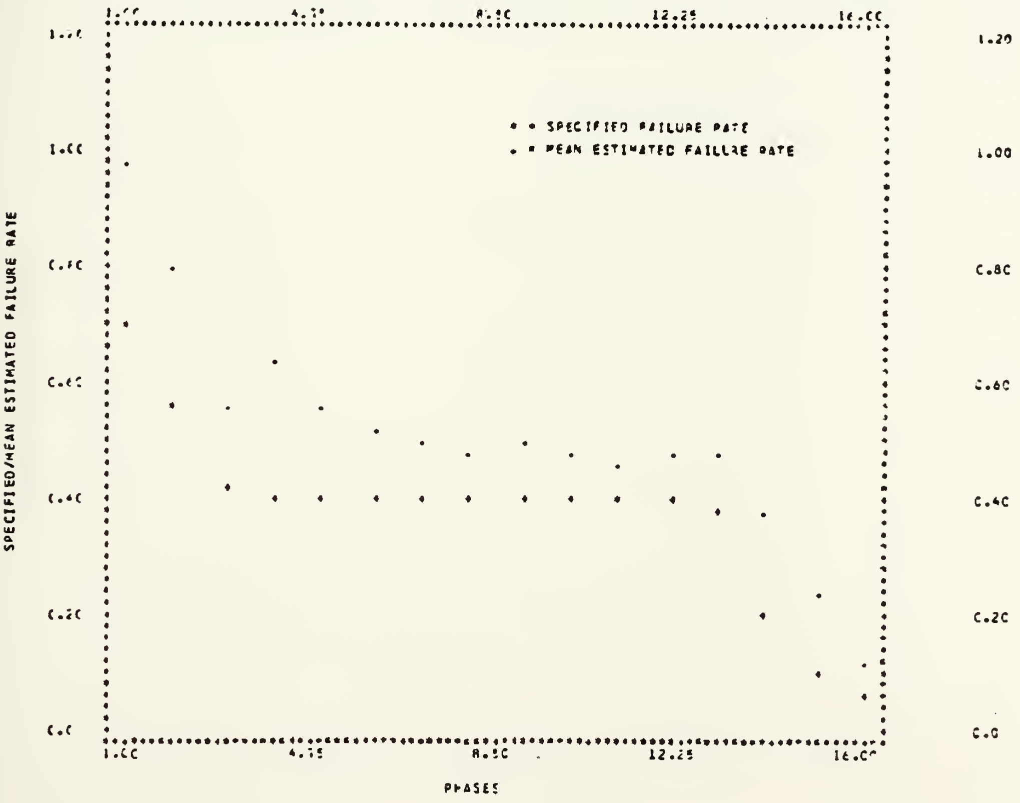
CASE 4

10 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.5500	0.4250	0.4050	0.4000	0.4000	0.4000	0.4000
PLANNED TEST TIME	0.2322	0.2555	0.3624	0.4013	0.4063	0.4063	0.4063	0.4063
MODEL ESTIMATE	0.9739	0.7946	0.5631	0.6317	0.5626	0.5103	0.4937	0.4734
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	39.13	44.48	32.50	55.97	40.65	27.59	23.43	18.35
SAMPLE STD DEVIATION	0.6085	0.3476	0.3305	0.6257	0.4219	0.3326	0.3359	0.2306
CUMULATIVE TEST TIME	2.136	4.887	8.462	12.133	15.883	19.633	23.410	27.199
CUMULATIVE FAILURES	1.5400	2.8500	4.1100	5.9000	7.3100	8.6400	10.3000	11.2700

* * *

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.4000	0.4000	0.3750	0.2000	0.1000	0.0500
PLANNED TEST TIME	0.4063	0.4063	0.4063	0.4063	0.4334	0.8126	1.6252	3.2504
MODEL ESTIMATE	0.4954	0.4719	0.4693	0.4749	0.4861	0.3763	0.2360	0.1286
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	23.85	17.97	17.32	18.74	29.64	88.13	135.98	157.29
SAMPLE STD DEVIATION	0.2732	0.2569	0.2628	0.2450	0.2440	0.2103	0.1032	0.0447
CUMULATIVE TEST TIME	30.943	34.723	38.455	42.187	46.178	53.627	68.585	98.391
CUMULATIVE FAILURES	13.0700	14.4500	16.0100	17.5700	19.1600	20.8000	22.3600	23.5300



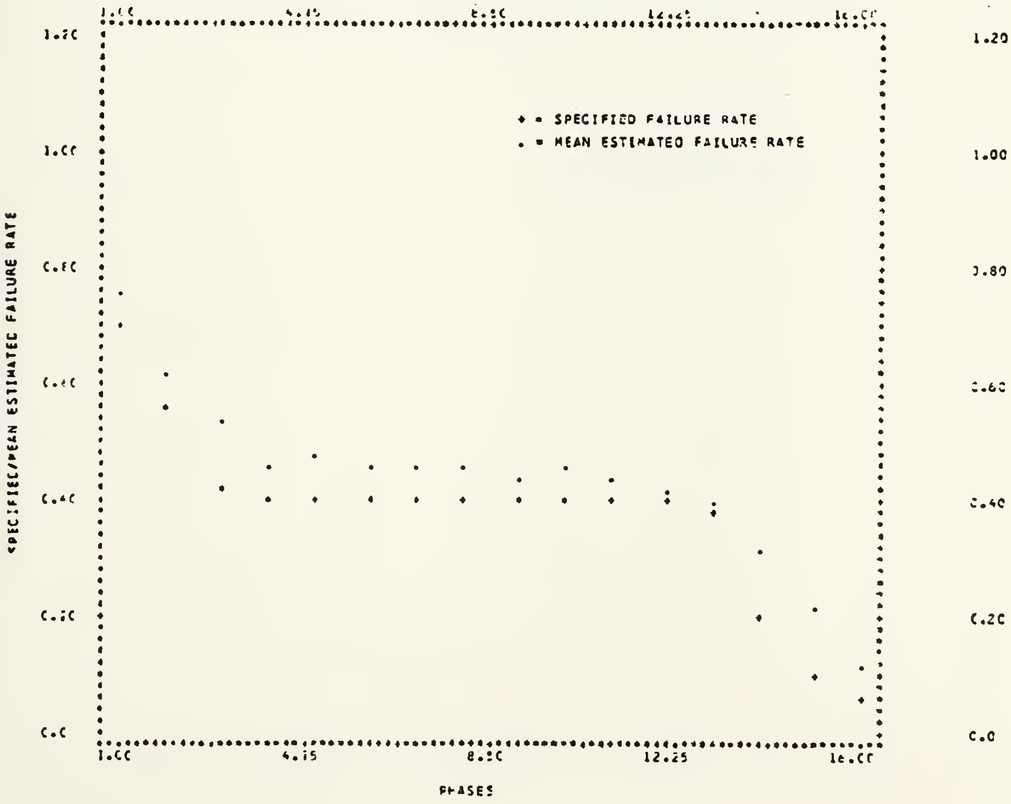
```
                                        CASE   4

                                        20 ITEMS

PHASE                             1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.7000    0.5500    0.4250    0.4050    0.4000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME          0.2322    0.2955    0.3824    0.4013    0.4063    0.4063    0.4063    0.4063
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              0.7576    0.6134    0.5322    0.4618    0.4705    0.4524    0.4506    0.4687
ESTIMATE  ERROR  AS            8.23     11.53     25.22     14.02     17.63     13.09     12.64     17.19
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         0.4180    0.3492    0.3033    0.2545    0.2521    0.2209    0.1825    0.1866
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME          4.313     9.758    16.874    24.303    31.756    39.327    46.755    54.188
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          2.9500    5.8600    8.8700   11.7100   14.7100   17.7600   20.8300   24.0300
------------------------------------------------------------------------------------------------------------

..................................................................................................................

PHASE                             9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.4000    0.4000    0.4000    0.4000    0.3750    0.2000    0.1000    0.0500
PLANNED  TEST  TIME          0.4063    0.4063    0.4063    0.4063    0.4334    0.8126    1.6252    3.2504
------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              0.4376    0.4504    0.4331    0.4219    0.4088    0.3298    0.2192    0.1282
ESTIMATE  ERROR  AS            9.40     12.59      8.28      5.47      9.03     64.91    119.21    156.45
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         0.1479    0.1569    0.1384    0.1203    0.1133    0.0867    0.0648    0.0387
------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         61.676    69.133    76.672    84.172    92.154   107.154   137.220   197.432
------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES         27.0400   30.2200   33.2300   36.1700   39.0600   42.0600   44.8000   47.8000
------------------------------------------------------------------------------------------------------------
```



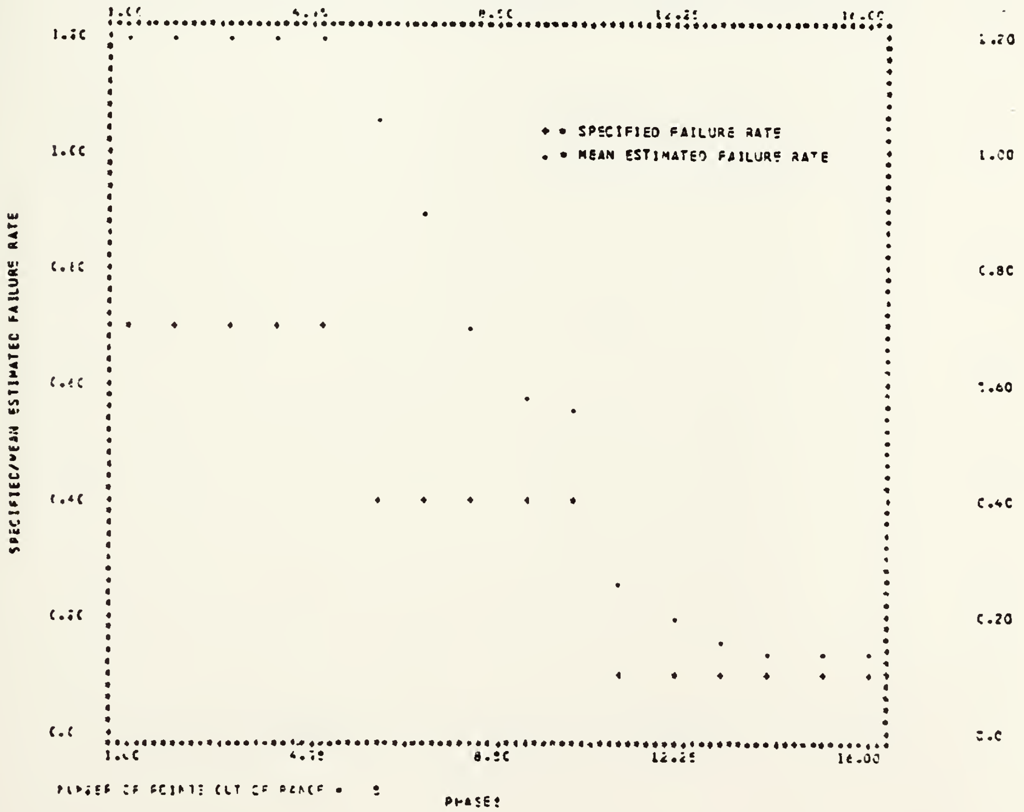
```
                                          CASE   6

                                          5 ITEMS

PHASE                         1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME      0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          1.3652    1.4585    1.3739    1.4043    1.3352    1.0660    0.9046    0.7035
ESTIMATE  ERROR  AS       95.03    108.36     96.28    100.61     90.74    166.51    126.16     75.88
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.6434    0.8648    0.7531    0.7801    0.6851    0.7149    0.6319    0.4647
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      1.061     2.128     3.209     4.305     5.374     7.210     9.075    10.968
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      0.7400    1.4100    2.1100    2.8400    3.5500    4.4600    5.1800    6.0100
------------------------------------------------------------------------------------------------------

**************************************************************************************************************

PHASE                         9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME      0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.5870    0.5612    0.2547    0.1974    0.1613    0.1387    0.1358    0.1407
ESTIMATE  ERROR  AS       46.75     40.30    154.71     97.37     61.33     38.75     35.79     40.72
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.3553    0.4226    0.1452    0.1285    0.0885    0.0777    0.0821    0.1032
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME     12.856    14.742    22.241    29.722    37.201    44.676    52.044    59.523
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      6.6800    7.3800    7.9800    8.9000    9.7000   10.4000   11.3000   12.1500
------------------------------------------------------------------------------------------------------
```



```
                                   CASE   6

                                   10 ITEMS

PHASE                        1         2         3         4         5         6         7         8
-----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.7000    0.7000    0.7000    0.7000    0.7000    0.4000    0.4000    0.4000
PLANNED  TEST  TIME       0.2322    0.2322    0.2322    0.2322    0.2322    0.4063    0.4063    0.4063
-----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.9152    0.9703    0.8404    0.9337    0.8485    0.5953    0.5030    0.4403
ESTIMATE  ERROR  AS        31.22     38.63     20.05     33.38     21.21     48.82     25.76     10.07
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.5079    0.5532    0.4066    0.4841    0.4528    0.3527    0.3424    0.2130
-----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       2.138     4.277     6.441     8.553    10.729    14.455    18.267    22.093
-----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.3900    2.9300    4.3100    5.9200    7.1800    8.6600    9.9800   11.2900
-----------------------------------------------------------------------------------------------------

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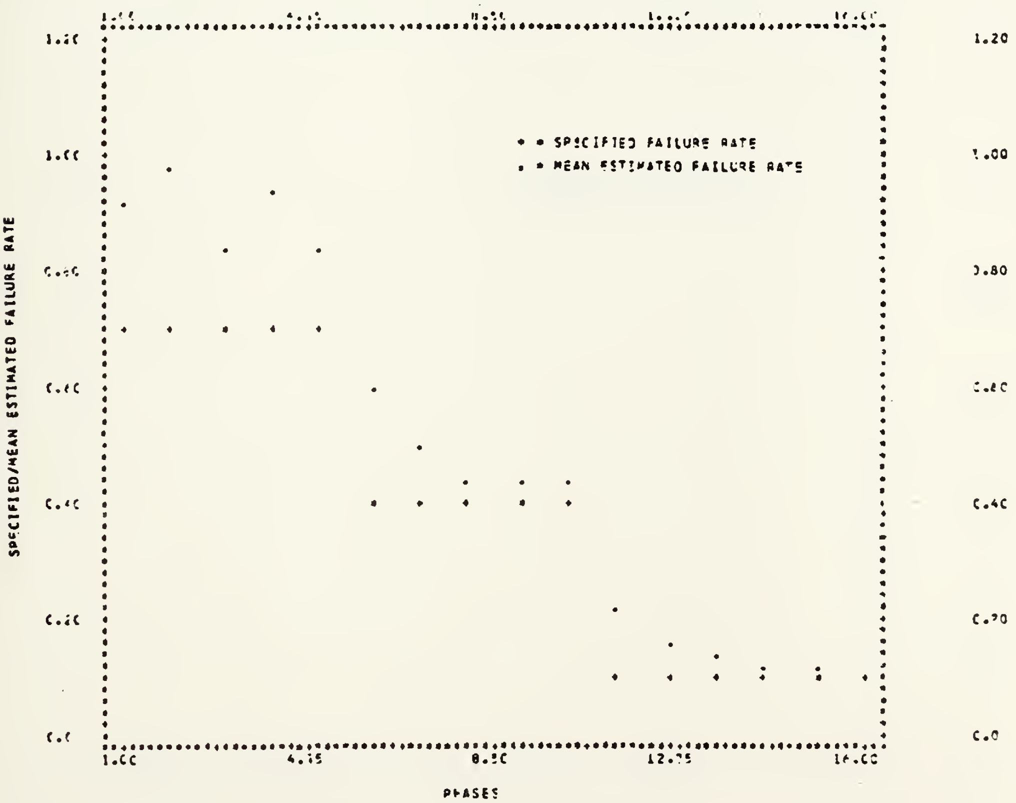
PHASE                        9        10        11        12        13        14        15        16
-----------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.1000    0.1000    0.1000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME       0.4063    0.4063    1.6252    1.6252    1.6252    1.6252    1.6252    1.6252
-----------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.4497    0.4308    0.2285    0.1646    0.1401    0.1240    0.1135    0.1098
ESTIMATE  ERROR  AS        12.43      7.71    128.46     64.57     40.12     24.01     13.51      9.77
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.2474    0.1931    0.1026    0.0577    0.0493    0.0446    0.0360    0.0331
-----------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      25.831    29.565    44.552    59.418    74.438    89.320   104.331   119.306
-----------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      12.7500   14.1900   15.7600   17.4500   19.0200   20.5800   22.1800   23.7400
-----------------------------------------------------------------------------------------------------
```



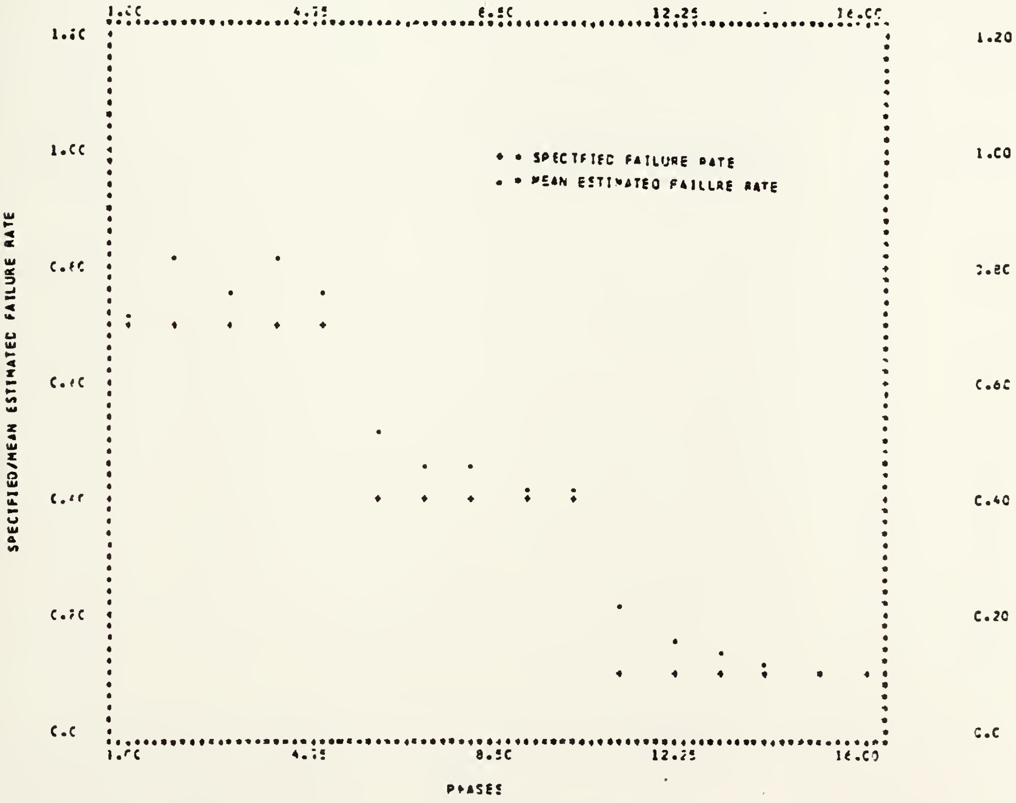
CASE 6

20 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.7000	0.7000	0.7000	0.7000	0.4000	0.4000	0.4000
PLANNED TEST TIME	0.2322	0.2322	0.2322	0.2322	0.2322	0.4063	0.4063	0.4063
MODEL ESTIMATE	0.7251	0.8171	0.7619	0.8146	0.7683	0.5247	0.4579	0.4588
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	3.58	16.72	8.84	16.37	9.76	31.16	14.48	14.64
SAMPLE STD DEVIATION	0.4087	0.4078	0.4044	0.4183	0.3747	0.2358	0.1844	0.1679
CUMULATIVE TEST TIME	4.294	8.561	12.842	17.130	21.419	28.905	36.410	43.631
CUMULATIVE FAILURES	2.7700	6.0000	9.2000	12.3000	15.2100	18.0700	21.0200	24.3000

……

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.4000	0.4000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.4063	0.4063	1.6252	1.6252	1.6252	1.6252	1.6252	1.6252
MODEL ESTIMATE	0.4149	0.4227	0.2133	0.1596	0.1348	0.1176	0.1079	0.1009
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	3.73	5.69	113.29	59.63	34.83	17.58	7.86	0.90
SAMPLE STD DEVIATION	0.1444	0.1487	0.0866	0.0491	0.0376	0.0322	0.0267	0.0219
CUMULATIVE TEST TIME	51.373	58.656	88.618	118.487	148.459	178.319	208.349	238.637
CUMULATIVE FAILURES	27.0300	30.0600	33.1700	36.4600	39.4300	42.3500	45.2600	48.2200

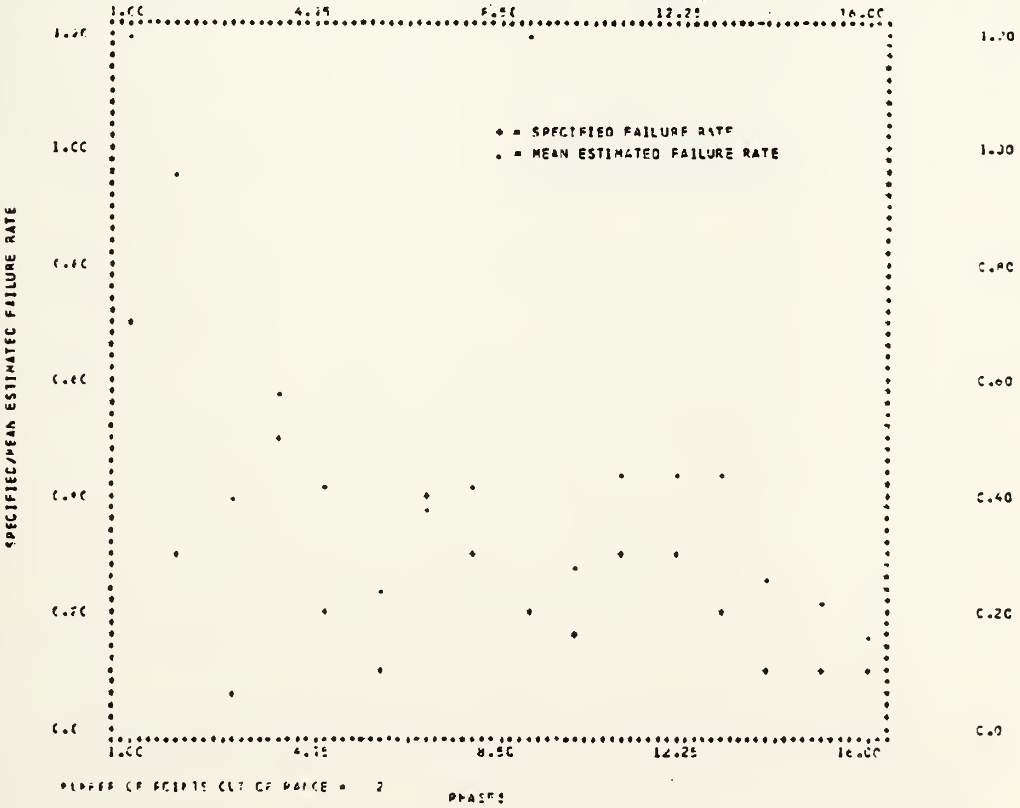


CASE 15

5 ITEMS

PHASE	1	2	3	4	5	6	7	8
ACTUAL FAILURE RATE	0.7000	0.3000	0.0500	0.5000	0.2000	0.1000	0.4000	0.3000
PLANNED TEST TIME	0.2322	0.5417	3.2504	0.3250	0.8126	1.6252	0.4063	0.5417
MODEL ESTIMATE	1.5230	0.9698	0.4066	0.5736	0.4183	0.2461	0.3870	0.4212
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	117.57	223.26	713.18	14.72	109.13	146.15	3.25	40.41
SAMPLE STD DEVIATION	1.0053	0.8302	0.8305	0.6133	0.4094	0.2845	0.4882	0.3911
CUMULATIVE TEST TIME	1.074	3.573	18.481	19.990	23.722	31.225	33.112	35.579
CUMULATIVE FAILURES	0.7500	1.4800	2.1600	2.9300	3.6500	4.4200	5.0500	5.8700

PHASE	9	10	11	12	13	14	15	16
ACTUAL FAILURE RATE	0.2000	0.1500	0.3000	0.3000	0.2000	0.1000	0.1000	0.1000
PLANNED TEST TIME	0.8126	1.0835	0.5417	0.5417	0.8126	1.6252	1.6252	1.6252
MODEL ESTIMATE	2.3376	0.2756	0.4459	0.4433	0.4311	0.2684	0.2146	0.1606
ESTIMATE ERROR AS PERCENTAGE OF ACTUAL FAILURE RATE	1068.78	83.72	48.62	47.76	115.55	168.36	114.63	60.60
SAMPLE STD DEVIATION	19.7454	0.2310	0.6655	0.2964	0.3810	0.2275	0.2007	0.1181
CUMULATIVE TEST TIME	39.391	44.288	46.786	49.254	53.005	60.484	68.057	75.729
CUMULATIVE FAILURES	6.3900	7.4200	8.3100	9.1000	9.8100	10.5100	11.3500	11.6500



```
                                   CASE  15

                                   10 ITEMS

PHASE                           1         2         3         4         5         6         7         8
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.7000    0.3000    0.0500    0.5000    0.2000    0.1000    0.4000    0.3000
PLANNED  TEST  TIME        0.2322    0.5417    3.2504    0.3250    0.8126    1.6252    0.4063    0.5417
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            1.0392    0.5182    0.0997    0.2490    0.2391    0.1900    0.3284    0.4017
ESTIMATE  ERROR  AS         48.46     72.74     99.36     50.20     19.55     90.02     17.89     33.90
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.5288    0.3643    0.1998    0.3890    0.2030    0.1798    0.2963    0.2972
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME        2.104     7.083    37.101    40.105    47.606    62.576    66.304    71.262
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES        1.7700    3.2400    4.8900    6.3000    7.9200    9.2800   10.9800   12.5500
---------------------------------------------------------------------------------------------------------

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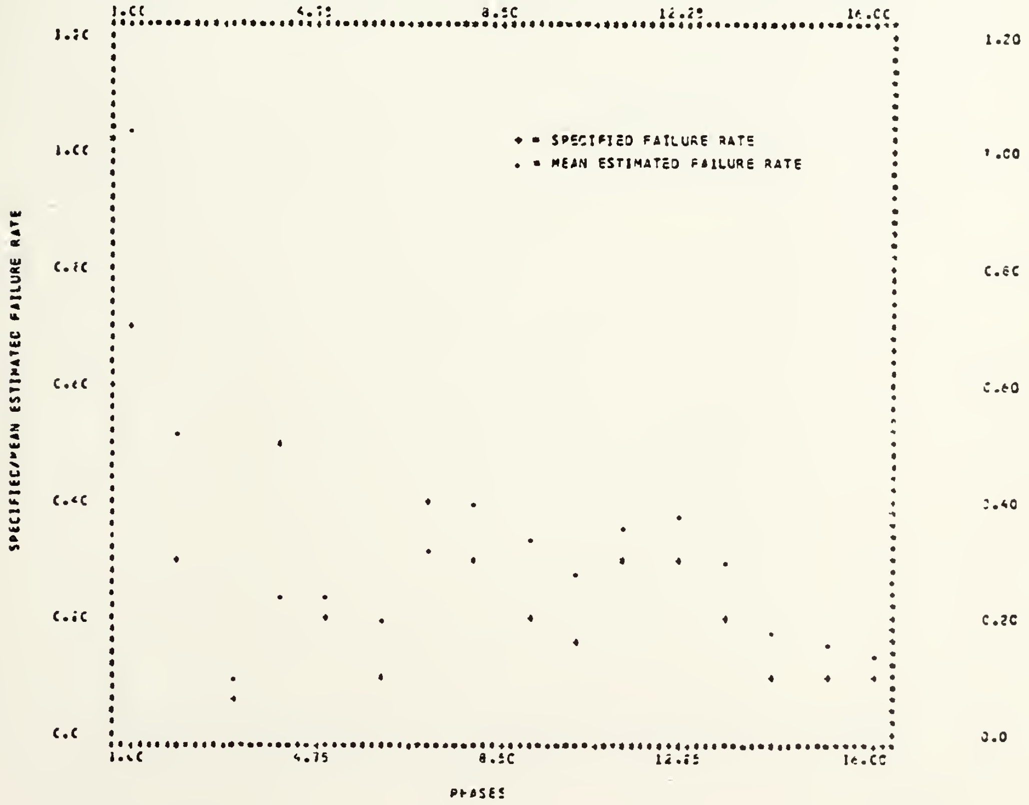
PHASE                           9        10        11        12        13        14        15        16
---------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE        0.2000    0.1500    0.3000    0.3000    0.2000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME        0.8126    1.0835    0.5417    0.5417    0.8126    1.6252    1.6252    1.6252
---------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE            0.2430    0.2760    0.3541    0.3718    0.2920    0.1863    0.1548    0.1419
ESTIMATE  ERROR  AS         21.52     84.03     18.03     23.95     46.01     86.28     54.77     41.92
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION       0.3097    0.2157    0.3028    0.2882    0.2416    0.0980    0.0762    0.0631
---------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       78.788    88.725    93.707    98.702   106.248   121.305   136.297   151.192
---------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       13.8300   15.4000   17.1800   18.6800   20.1100   21.4200   23.2900   24.8700
---------------------------------------------------------------------------------------------------------
```



```
                                     CASE  15

                                     20 STEPS

PHASE                         1         2         3         4         5         6         7         8
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.7000    0.3000    0.0500    0.5000    0.2000    0.1000    0.4000    0.3000
PLANNED  TEST  TIME      0.2222    0.5417    3.2504    0.3250    0.8126    1.6252    0.4063    0.5417
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.7622    0.4386    0.0605    0.1631    0.2373    0.1618    0.3324    0.3643
ESTIMATE  ERROR  AS        8.89     46.19     20.98     67.39     18.66     61.78     16.89     21.44
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.4209    0.3152    0.0356    0.2237    0.1373    0.1054    0.3696    0.1831
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      4.272    14.288    74.066    80.098    95.034   124.511   132.346   142.278
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      2.9900    5.8100    9.0000   11.7600   14.8800   18.0900   21.3200   24.4900
------------------------------------------------------------------------------------------------------

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PHASE                         9        10        11        12        13        14        15        16
------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE      0.2000    0.1500    0.3000    0.3000    0.2000    0.1000    0.1000    0.1000
PLANNED  TEST  TIME      0.8126    1.0835    0.5417    0.5417    0.8126    1.6252    1.6252    1.6252
------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE          0.2951    0.2206    0.2749    0.3298    0.2730    0.1752    0.1454    0.1323
ESTIMATE  ERROR  AS       47.55     47.05      8.37      9.93     36.52     75.21     45.38     32.26
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION     0.1676    0.1087    0.1547    0.2071    0.1417    0.0763    0.0586    0.0471
------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME    157.243   177.242   187.247   197.196   212.194   242.173   272.298   302.306
------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES     27.4000   30.4300   33.4100   36.6600   39.6100   42.6600   45.4900   48.4300
------------------------------------------------------------------------------------------------------
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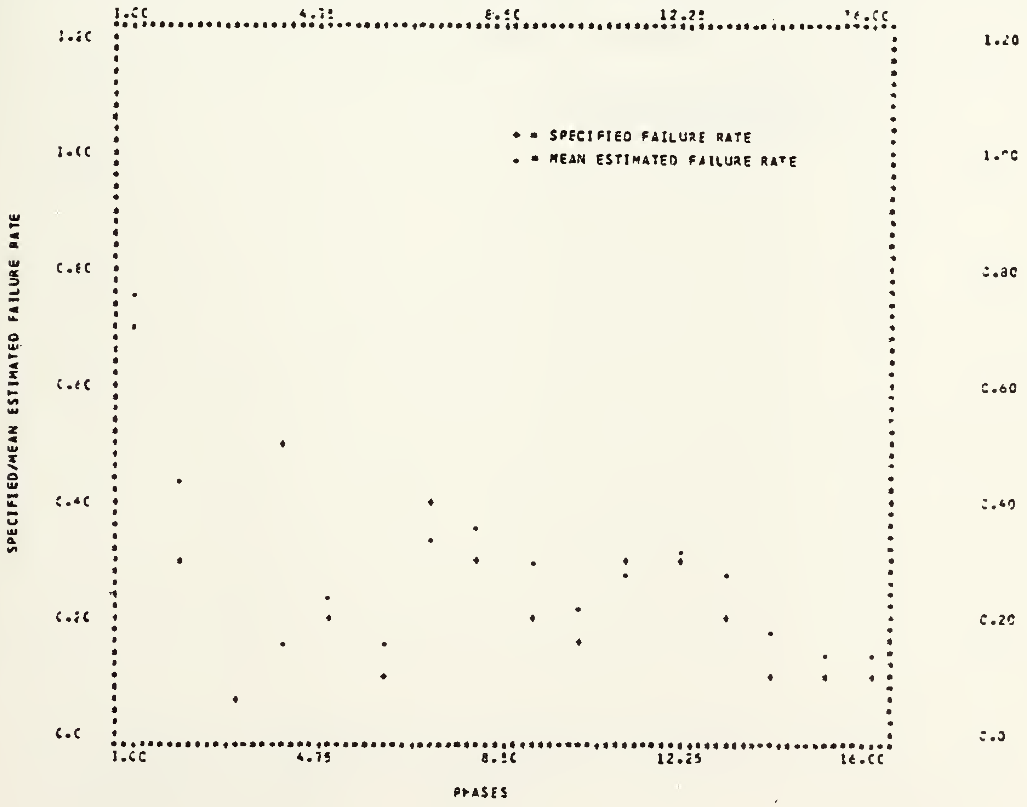

```
                                   CASE  18

                                   5 ITEMS

PHASE                             1          2          3          4          5          6          7          8
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.3000     0.3000     0.3000     0.3000     0.7000     0.7000     0.7000     0.7000
PLANNED  TEST  TIME          0.5417     0.5417     0.5417     0.5417     0.2322     0.2322     0.2322     0.2322
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              0.8056     0.5759     0.6478     0.6385     0.9375     1.2371     1.2028     1.2373
ESTIMATE  ERROR  AS          168.53      91.96     115.93     112.83      33.93      76.73      71.82      76.76
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         0.3824     0.3068     0.3914     0.3928     0.6532     0.8600     0.8665     0.8507
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME          2.209      5.042      7.507     10.020     11.119     12.158     13.223     14.288
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          0.7100     1.3300     2.1800     2.8300     3.4000     4.3900     5.1300     6.0800
-----------------------------------------------------------------------------------------------------------------

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PHASE                             9         10         11         12         13         14         15         16
-----------------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE          0.4000     0.4000     0.4000     0.4000     0.0500     0.0500     0.0500     0.0500
PLANNED  TEST  TIME          0.4063     0.4063     0.4063     0.4063     3.2504     3.2504     3.2504     3.2504
-----------------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE              0.9224     0.8152     0.7253     0.6333     0.1795     0.1123     0.0782     0.0673
ESTIMATE  ERROR  AS          130.59     103.80      81.33      58.33     259.06     124.64      56.41      34.60
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION         0.8110     0.5379     0.5256     0.3740     0.0898     0.0621     0.0224     0.0259
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME         16.166     18.027     19.941     21.804     36.765     51.970     67.164     82.335
-----------------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES          6.7800     7.5300     8.2700     8.9700     9.8100    10.6000    11.2000    11.9700
-----------------------------------------------------------------------------------------------------------------
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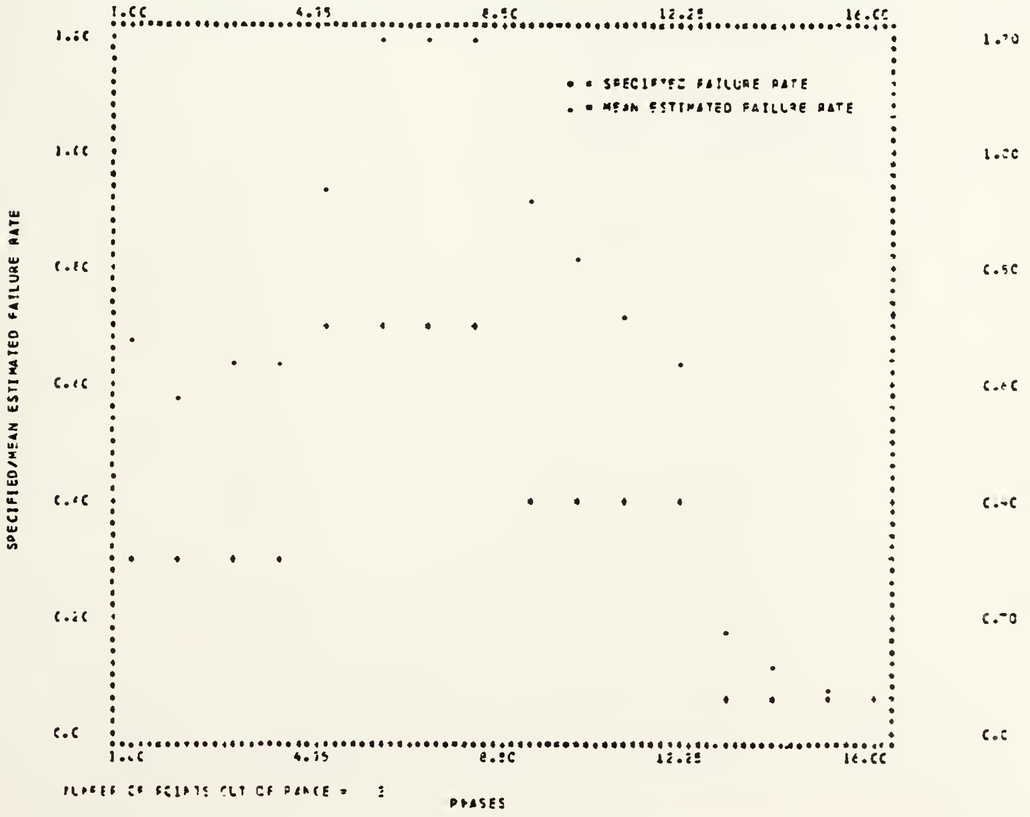

```
                                        CASE  18

                                        10 ITEMS

PHASE                          1         2         3         4         5         6         7         8
-------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.3000    0.3000    0.3000    0.3000    0.7000    0.7000    0.7000    0.7000
PLANNED  TEST  TIME       0.5417    0.5417    0.5417    0.5417    0.2322    0.2322    0.2322    0.2322
-------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.4091    0.3941    0.4895    0.4951    0.7469    0.7703    0.8223    0.9147
ESTIMATE  ERROR  AS        36.38     31.37     63.17     65.02      6.70     10.04     17.47     30.67
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.2190    0.2343    0.3764    0.2533    0.5928    0.4669    0.4535    0.5060
-------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       4.927     9.932    14.858    19.747    21.909    24.061    26.213    28.341
-------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       1.9900    2.9700    4.7200    6.5600    7.9700    9.1400   10.5900   12.4700
-------------------------------------------------------------------------------------------------------

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PHASE                          9        10        11        12        13        14        15        16
-------------------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000    0.4000    0.4000    0.4000    0.0500    0.0500    0.0500    0.0500
PLANNED  TEST  TIME       0.4063    0.4063    0.4063    0.4063    3.2504    3.2504    3.2504    3.2504
-------------------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.6387    0.4985    0.4821    0.4680    0.1470    0.0945    0.0759    0.0616
ESTIMATE  ERROR  AS        59.67     24.63     20.53     16.99    194.08     89.02     51.82     23.19
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.3417    0.2025    0.2164    0.1934    0.0787    0.0633    0.0565    0.0276
-------------------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      32.123    35.920    39.705    43.459    73.610   103.736   133.735   163.966
-------------------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      13.8200   15.0600   16.5900   18.0700   19.4800   20.8400   22.3300   23.8200
-------------------------------------------------------------------------------------------------------
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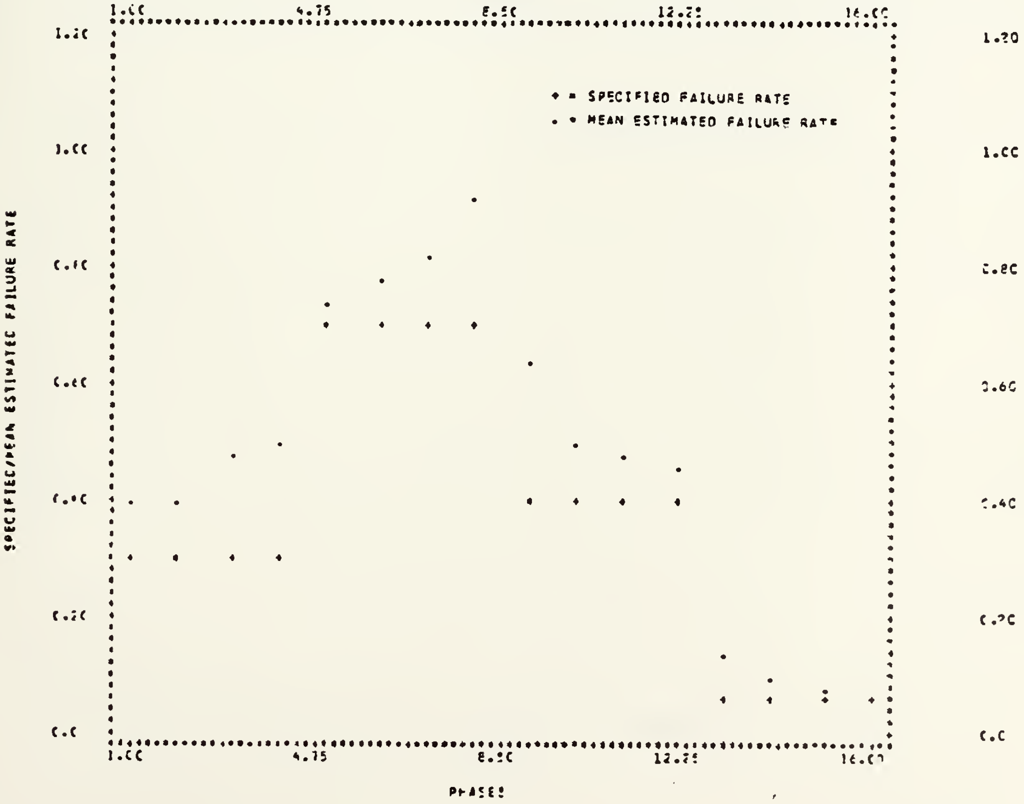


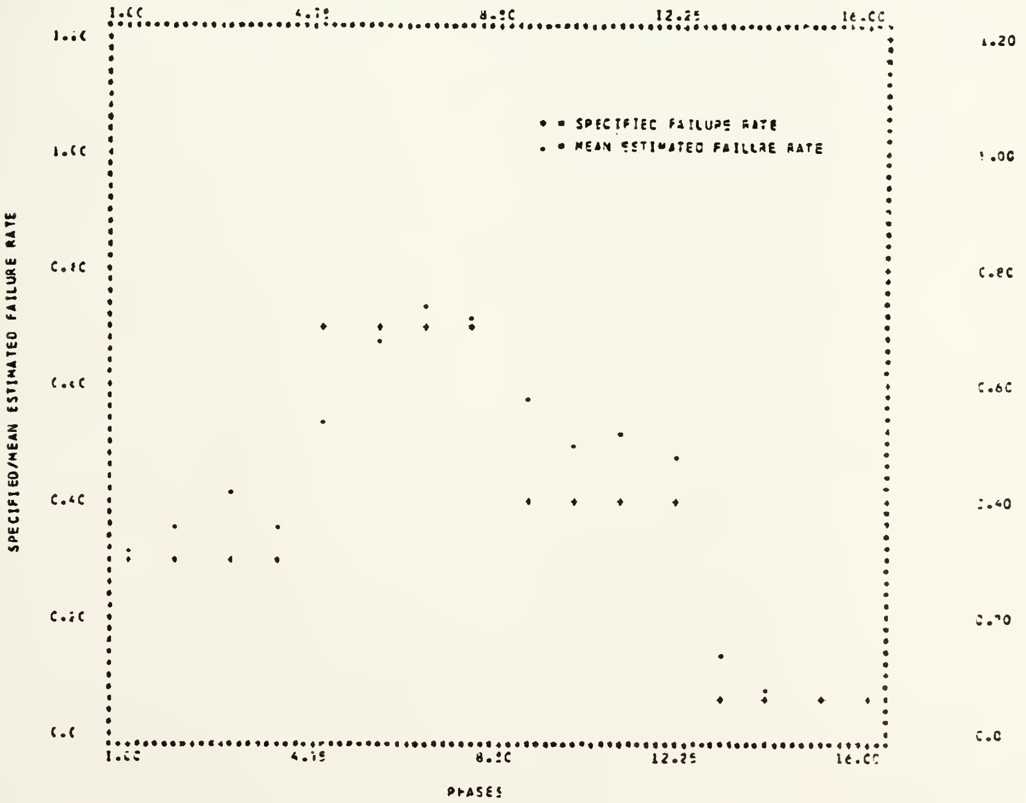
CASE 18

20 ITEMS

```
PHASE                          1        2        3        4        5        6        7        8
-----------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.3000   0.3000   0.3000   0.3000   0.7000   0.7000   0.7000   0.7000
PLANNED  TEST  TIME       0.5417   0.5417   0.5417   0.5417   0.2322   0.2322   0.2322   0.2322
-----------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.3215   0.3610   0.4102   0.3591   0.5376   0.6789   0.7301   0.7270
ESTIMATE  ERROR  AS         7.16    20.34    36.75    19.77    23.21     3.02     4.30     3.86
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.1815   0.2143   0.3210   0.1976   0.2854   0.3245   0.4018   0.3486
-----------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME       5.556   19.586   29.850   39.908   44.206   48.435   52.744   57.035
-----------------------------------------------------------------------------------------------
CUMULATIVE FAILURES       3.3300   5.9000   9.1800  12.0600  14.8100  18.1200  21.0300  23.5500
-----------------------------------------------------------------------------------------------
```

....

```
PHASE                          9       10       11       12       13       14       15       16
-----------------------------------------------------------------------------------------------
ACTUAL FAILURE RATE       0.4000   0.4000   0.4000   0.4000   0.0500   0.0500   0.0500   0.0500
PLANNED  TEST  TIME       0.4063   0.4063   0.4063   0.4063   3.2504   3.2504   3.2504   3.2504
-----------------------------------------------------------------------------------------------
MODEL  ESTIMATE           0.5738   0.5011   0.5129   0.4748   0.1374   0.0874   0.0693   0.0587
ESTIMATE  ERROR  AS        43.46    25.28    28.22    18.70   174.86    74.82    38.64    17.42
PERCENTAGE OF ACTUAL
FAILURE RATE
SAMPLE STD DEVIATION      0.2710   0.2315   0.2284   0.1613   0.0597   0.0360   0.0251   0.0188
-----------------------------------------------------------------------------------------------
CUMULATIVE TEST TIME      64.565   72.051   79.547   87.097  147.563  208.226  267.736  327.823
-----------------------------------------------------------------------------------------------
CUMULATIVE FAILURES      26.9100  29.8600  33.1100  36.0300  38.5000  41.5400  44.6200  47.5000
-----------------------------------------------------------------------------------------------
```



LIST OF REFERENCES

1. Military Handbook for Reliability Growth Management, Proposed MIL-HDBK-XXX, 7 July 1978.

2. Crow, L. H., 1975, "On Tracking Reliability Growth", Proceedings 1975 Annual Reliability and Maintainability Symposium.

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